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TREE DISTRIBUTION IN CENTRAL CALIFORNIA

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IT has frequently been observed that the shrubs in dry regions occur isolated from one another, with the effect that the landscape as a whole has a spotted appearance. This in certain regions is very striking. For example, on drainage slopes or bajadas of the mountains of southern Arizona or southern California, one sees a discontinuous vegetal covering, conveying the idea that there are more plants than is actually the case. The remote cause of the sparseness of such plant covering, as is well known, is to be traced to a precipitation amount which is inadequate to support a dense shrub population. The immediate cause, however, is to be sought in competition between plants for ground water. The roots of neighboring plants intermingle and lie in the same soil horizon, seeking the same soil moisture. Such shrubs as have the most efficient root system, either as seedlings or mature forms, survive. Thus, here, as elsewhere in nature, the victory is to those which are best adapted to the particular environment.

As one leaves such marked arid regions behind, and journeys to regions which are less arid, as in the valleys of Central California, the interrupted distribution of the shrubs gives way to a dense shrub population, the chaparral, or pygmy forest. But in this portion of California one finds trees growing in open forests with park-like effect, in a manner exactly comparable to the open stand of the desert shrubs. This observation applies to the valley floors or the lower slopes of the mountains or low hills. In the more moist regions, as in the mountains, forest covering may be relatively, or actually, dense. Also the species to which the observation applies are, in the main, oaks. It will be shown in this note that the three species of oaks especially spoken of will have each a different and characteristic distribution and will have a different and characteristic relation one to another. It will also be shown that these are in part dependent on the character of the root-systems of the

Fig. 1. Cultivation in a Natural "Forest" in the Salinas Valley, Central California. The open stand is characteristic of the groves of the coastwise valleys. The taller centrally placed trees of the figure are *Quercus lobata*, the roble oak, and the others are *Q. agrifolia*, the encina oak.

species, as well as on the depth to perennial soil-moisture, or in other words, the water relation.

The three species of oaks referred to are *Quercus agrifolia,* the encina oak, *Q. lobata,* the roble oak, and *Q. Douglasii,* the blue or Douglas oak. The roble oak and Douglas oak are deciduous. The encina oak is the familiar live-oak of the coastwise valleys.

The roble oak is the valley oak *par excellence,* and is probably the largest California species of the genus. The largest specimen reported is 150 feet in height and 25 feet in circumference four feet above the ground.[1] The writer also saw a specimen near Clear Lake, which had a spread of top estimated to be 144 feet. In addition to being of large size, the roble oak is unusually beautiful and graceful, with long and slender pendant secondary branches, which occasionally nearly sweep the ground. If not strictly confined to moist soils, it at least attains its best development where the soil is moist and the depth to the level of perennial water is not so great as to be beyond the reach of the roots.

The encina oak is the species characteristic of the valleys of the coast ranges, where it finds its greatest development. It is disposed in open groves and it is to this species, mainly, that the park-like appearance of the coast valleys is due. In form, the encina oak is more compact than the roble oak, and has low, rounded tops, as is indicated by the accompanying figure.

As distinguished from the two other species of oaks just mentioned, the blue oak occurs characteristically on dry, rocky soils, "which are excessively arid in the rainy season."

> Not in itself an attractive tree, the blue oak, by reason of its form, color and habit, plays a strong and a natural part in the scenery of the yellow-brown foothills.[2]

Like the encina oak, the blue oak occurs singly or in open groves. The characteristic appearance of the tree and its distribution are shown in Figure 1.

However the species of oaks may differ from one another in habit, or however different the habitats they frequent may be, they agree in the one particular which has already been mentioned, namely, in the open character of the stand. This phase of the study of the oaks received particular attention at the hands of the writer in 1913, and the leading conclusions will be presented in the subsequent paragraphs.

Quercus lobata

An examination of the roots of the three species shows a striking difference in the position occupied by them in the ground, as well as in the general character of development. That of the roble oak is more of

1 Jepson, "The Sylva of California."

2 Jepson, *l. c.*

FIG. 2. ROOTS OF *Quercus lobata* GROWING BY A STREAM IN LAKE COUNTY. Owing to the washing away of the bank the tree has lost a portion of its former support and has leaned toward the streamway. The generalized character of the root system is fairly well shown.

the usual type, in that there is large development of the tap-root, from which extend at various depths large laterals in comparatively large numbers. The secondary roots may also penetrate fairly deep, although occasionally they lie near the surface also. In large specimens, superficial roots as long as 70 feet have been observed. Secondary roots usually branch relatively little. In a word, the root-system of the roble oak is especially well adjusted to take advantage of the more deeply-lying soil moisture, while at the same time the more superficially placed roots can absorb water from the more superficial soil layers. As will be shown below, the root habit of the plant is one well calculated to close adjustment with the peculiar habitat frequented by the species.

Quercus agrifolia

The root-system of the encina oak is characterized by an especially well-developed superficial portion, which consists of numerous relatively short and relatively slender roots, which are placed, for the most part, within three feet of the surface of the soil. There are also more deeply penetrating roots, but these are relatively few in number. In young

trees, however, the tap-root, or a few laterals, are rather deeply placed, and appear to predominate in numbers. The formation of the more superficial portion of the root-system, therefore, is a response which comes with the aging of the tree. In the case of the blue oak also, there can be traced a very intimate relation between root character of the open stand of forest and the water relation.

Quercus Douglasii

As in the case of the root-system of the roble oak, that of the blue oak is composed of relatively few roots, which are usually coarse. The tap-root is sometimes well developed and there are relatively few laterals. The root-system of the blue oak, however, differs from that of the roble oak in that the roots of the species, in the proper habitat, are confined to the upper soil strata. The tap-root is also shallowly placed. The relation of the roots of the blue oak, as well as the root-system of the two other species, to soil moisture, will be taken up immediately.

Root Variation

The brief characterization of the root-systems of the oaks, as just given, does not take into account the possible variation of the roots. Owing to the impracticability of excavating the roots, it was impossible to study the variation exactly. For some reasons, however, it does not seem probable that there is marked variation in root type.

Fig. 3. Superficial Absorbing Roots of *Quercus agrifolia* Growing on the Lower Slope of the Santa Cruz Mountains near Stanford University.

For example, when the roble oak and the encina oak are growing together, and the ground is cultivated beneath them, there is a difference in response of the cultivated plants, which appears not to be directly traceable to the fact that one of the oaks is deciduous and the other is evergreen. Thus, it is known that such cultivated plants, when given water artificially, may thrive beneath the roble oak, while they may dry readily beneath the encina oak, thus indicating that the roble oak does not form a marked superficial root system, even under such conditions. Under such conditions, also, the encina oak absorbs water freely and grows vigorously. Whether, on the other hand, the

FIG. 4. *Quercus Douglasii* ON AN ARID HILL NEAR SAN MIGUEL, WHERE THE WATER TABLE LIES AT A DEPTH OF ABOUT 75 FEET. The shallow placing of the roots, as well as their general character, are shown in the figure.

converse condition would obtain if *agrifolia* were grown in the habitat especially characteristic of *lobata* has not been observed. From the nature of the development of the root system of the species, and its plasticity, this might be expected. The characteristic root development of the blue oak would lead one to suspect, also, that, given abundant soil moisture and adequate depth of soil, the roots might be induced to penetrate deeply. This condition, however, has not been actually observed.

GROUND WATER

The depth to the water table in the valleys is variable, and, in the habitats characteristic of the three species of oaks, unlike. In the

valleys inhabited by *Quercus agrifolia,* the water table usually lies 35 feet or more beneath the surface. Sometimes it is much greater than this, although it is rarely less. The availability of the soil moisture which is derived from the water table to the roots does not depend wholly upon the depth of the water table, but largely on the character of the soil which intervenes between the plant roots and the water table. For example, there may be strata of sand or gravel above the level of perennial water which effectually separate the water table from the root system. For this reason, the depth to perennial ground water is not always of itself a criterion as to whether the moisture is available to the plant or not. In such cases, as has been intimated above, the plants are wholly dependent upon the water coming directly from the rains or on what water is derived from run-off or by seepage from higher ground. This, for the most part, does not penetrate beyond approximately 3 to 4 feet. The plant, therefore, is obliged to develop an extensive superficial system, in order to make use of such surface water. For this reason, the roots of adjacent trees compete for the ground water in a manner exactly comparable to the competition, as already pointed out, which occurs among the desert shrubs. Thus it follows that, because of a relative paucity of water, the trees come to have an open stand.

In the habitats where *Q. Douglasii* occurs, the water table is wanting, or so deeply placed as to be quite beyond the possible reach of the plant's roots, so that here again, the species is wholly dependent on surface water for its water supply. It follows, therefore, that the blue oak forms a very open stand, as has been seen to be the case in the encina oak, and for the same reason.

The conditions of the water supply of the roble oak, on the other hand, are diametrically opposed to those of the two other species. The best development of the roble oak occurs where the perennial ground water lies within 10 to 20 feet of the surface of the soil, or where the soil is practically homogeneous, so that the ascent of capillary water is great and where it is possible for the roots of the species to penetrate to a great depth. A characteristic example of this species, although of medium size, was seen by the edge of Putah Creek, where the July-level of the stream was less than twelve feet beneath the surface of the flood-plain, and where the flood-level of the stream must occasionally have washed the base of the tree itself.

From this brief outline of the root-characters of the three most prominent species of oaks of Central California and from the sketch of the ground water relations of the species, it appears that there is an intimate relationship between root character and the characteristic local distribution of the species.

The Relation of Ground Water to Forest Distribution

It has been pointed out in another place[3] that the depth to perennially moist soil, which is usually regulated by the depth of the water table, undoubtedly plays an important rôle in the distribution of forests as a whole. Thus, where the moist soil lies too deep to be tapped by the roots of the trees, other factors being equal, forests are usually wanting, but where the water table lies near enough to the surface, so that the perennially moist soil above it can be reached by the roots of the trees, forests are present. In southern Arizona it has been found that, given a practically homogeneous soil, the mesquite assumes a tree habit with the water 35 feet, more or less, beneath the surface, but that where the soil is not homogeneous, and is stratified, so that a portion of the strata are dry, or where the water table is more than 35 to 40 feet beneath the surface, the species has a shrub-like habit. An analogous condition obtains in the coastal plain of Texas and in the treeless middle-west. In the latter region the deciduous forests are almost wholly confined to the flood-plains of streams, while the adjacent upland is treeless. Thus, over a wide area where the climate is arid or semi-arid, the depth to perennial water is an important factor in determining the presence of forests. Where the trees are unable to attain to such moist soil, they usually develop xerophytic characters or special adjustments by which they are enabled to survive. How true this generalization may be found to be can not at present be told, but that it applies to such regions as central California, there can be no doubt. Among the adjustments, as has been pointed out in this note, are to be included those of the root-system by which they are especially adapted to make use of the superficial waters.

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[3] *Science*, N. S., Vol. XXXVII., p. 420, 1913.

PHENOMENA OF INHERITANCE

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II. Modifications and Extensions of Mendelian Principles

IT is a common experience that natural phenomena are found to be more complex the more thoroughly they are investigated. Nature is always greater than our theories, and with few exceptions hypotheses which were satisfactory at one stage of knowledge have to be extended, modified or abandoned as knowledge increases. This observation is well illustrated in the case of the Mendelian theory. The principles proposed by Mendel were relatively simple, but in attempting to apply them to the many phenomena of inheritance now known it has become necessary to modify or extend them in many ways. And yet the general and fundamental truth of these principles has been established in a surprisingly large number of cases, and they have been extended to forms of inheritance where at first it was supposed that they could not apply.

1. *The Principle of Unit Characters and Inheritance Factors.*—There has been much criticism on the part of some biologists of the principle of unit characters. It is said that unit characters can not be independent and discrete things; the organism itself is a unity and every one of its parts, every one of its characters, must influence more or less every other part and every other character. Certainly unit characters can not be absolutely independent of one another; the various parts and organs of the body and even the organism, as a whole, is not absolutely independent, and yet there are varying degrees of independence in organisms, organs, cells, parts of cells, hereditary units and characters which make it possible for purposes of analysis to deal with these things as if they were really independent, though we know they are not.

Of course characters of adult individuals do not exist as such in germ cells, but there is no escape from the conclusion that in the case of inherent differences between mature organisms there must have been differences in the constitution of the germ cells from which they developed. For every inherited character there must have been a germinal cause in the fertilized egg. This germinal cause, whatever it may be, is often spoken of as a *determiner* of a character. But the character in question is not to be thought of as the result of a single cause nor

as the product of the development of a single determiner; undoubtedly many causes are involved in the development of every character, but the *differential* cause or combination of causes is that which is peculiar to the development of each particular character.

Again it is not necessary to suppose that every developed character is represented in the germ by a distinct determiner, or inheritance unit, just as it is not necessary to suppose that every chemical compound contains a peculiar chemical element; but it is necessary to suppose that each hereditary character is caused by some particular combination of inheritance units and that each compound is produced by some particular combination of chemical elements. An enormous number of chemical compounds exists as the result of various combinations of some eighty different elements, and an almost endless number of words and combinations of words—indeed, whole literatures—may be made with the twenty-six letters of the alphabet. It is quite probable that the kinds of inheritance units are few in number as compared with the multitudes of adult characters, and that different combinations of the units give rise to different adult characters; but it is certain that every inherited difference in adult organization must have had some differential cause or factor in germinal organization.

Mendel did not speculate about the nature of hereditary units, though he evidently conceived that there was something in the germ which corresponded to each character of the plant. Weismann postulated a determinant in the germ for every character which is independently heritable, and many recent students of heredity hold a similar view.

But it is evident that there is not an exact one-to-one correspondence of inheritance units and adult characters. Many characters may be decided by a single unit or factor; for example, all the numerous secondary sexual characters which distinguish males from females are decided by the original factor which determines whether the germ cells shall be ova or spermatozoa.

On the other hand, two or more factors may be concerned in the production of a single character. In many cases among both plants and animals the development of color appears to depend upon the presence in the germ cells and the cooperation in development of at least two factors, viz. (1) a pigment factor P (for black B, for brown Br, for yellow Y, for red R, etc.), and (2) a color developer C. When both of these factors are present color develops; when either one is absent no color appears.

Such cases have been described for mice, guinea-pigs and rabbits as well as for several species of plants. Bateson and Punnett found two varieties of white sweet peas which were apparently alike in every respect except the shapes of their pollen grains, one of them having long

and the other round pollen. But when these were crossed a remarkable thing occurred, for the progeny, "instead of being white, were purple, like the wild Sicilian plant from which our cultivated sweet peas are descended." This is apparently a typical case of reversion and its cause was found in the fact that *at least* two factors are necessary in this case for the production of color, a pigment factor R and a color developer C. One of these was lacking in each of the white parents, their gametic formulæ being Cr and cR, but when these two factors came together in the offspring a purple-flowered type was produced with the gametic formula $Cc\ Rr$. These F_3 plants produced colored and white F_3 plants in the proportion of 9 colored: 7 white and the colored forms were of six different kinds (Fig. 57). For the production of these six colored forms five different factors must be present in the gametes, according to Punnett, viz.: (1) a color base (R), (2) a color developer C, (3) a purple factor B, (4) a light wing factor L, (5) a factor for intense color I. When all of these factors are present the result is the purple wild form with blue wings, while the omission of one or more of these factors leads to the production of six forms of colored and various types of white flowered plants of the F_2 generation.

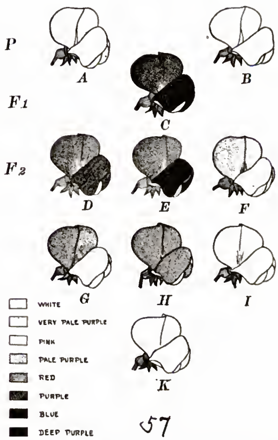

FIG. 57. RESULTS OF CROSSING TWO DIFFERENT RACES (A) AND (B) OF WHITE SWEET PEAS; all the F_1 hybrids (C) are purple with blue wings like the wild ancestral stock; in F_2 six colored varieties are formed ranging from purple with blue wings (D) to tinged white (I) and several kinds (genotypes) of white varieties (K). (After Punnett.)

Castle found that eight different factors may be involved in producing the coat colors of rabbits; these are:

- C a common color factor necessary to produce any color.
- B a factor acting on C to produce *black*.
- Br a factor acting on C to produce *brown*.
- Y a factor acting on C to produce *yellow*.
- I a factor which determines *intensity* of color.
- U a factor which determines *uniformity* of color.
- A a factor for *agouti*, or wild gray pattern, in which the tip of every hair is black, below which is a band of yellow, while the basal part of the hair is gray.

E a factor for the extension of black or brown but not of yellow.

Plate found that all of these factors except the last, E, are also involved in the production of the coat colors of mice. Baur has recognized more than twenty different factors for the color and form of flowers in the snap-dragon, *Antirrhinum*.

These factors are probably complex chemical substances which preserve their individuality in various combinations, just as groups of atoms or radicals do in chemical reactions; they may be dropped out or added, substituted or transposed, just as chemical radicals may be in chemical compounds. To this extent they maintain continuity and independence, but they are not absolutely independent, for they react upon one another as well as to environmental changes, so that the characters of the developed organism are the results of all these reactions and interactions.

Inheritance Factors and Germinal Units

It is obvious that there must be things in germ cells which correspond to the inheritance factors; furthermore, these things must be material particles even though they be only atoms or molecules and their combinations or dissociations. And yet there are many students of the phenomena of heredity who know little about germ cells and to whom all parts of a cell are hypothetical structures, to whom "chromosomes are articles of faith," and who protest rather violently against any attempt to find the factors of inheritance in any of the structures of the germ cells. And yet it is perfectly evident that if there are inheritance units they must exist in the germ cells as discrete particles, even if they are only molecules, by whose associations or dissociations in response to intrinsic or extrinsic conditions the various characters of the developed organism arise. It is certainly legitimate to ask what the germinal elements are which correspond to inheritance factors.

There was a time when the cell was the *ultima thule* of biological analysis and when the contents of cells were supposed to be "perfectly homogeneous, diaphanous, structureless slime." Then the nucleus was discovered within the cell, then the chromosomes within the nucleus, then the chromomeres within the chromosomes, and there is no reason to suppose that organization ceases with the powers of our present microscope. With every improvement of the microscope and of microscopical technique, structures have been found in cells which were undreamed of before, and it is not probable that the end has been reached in this regard. We know that cells contain nuclei and chromosomes and chromomeres, centrosomes and plastosomes and microsomes, and we know that some of these parts differ in function as well as in structure. And there is no reason to doubt that if we had sufficiently powerful microscopes we should find still smaller and smaller units until we came at last to molecules and atoms.

The manner in which inheritance units from the two parents unite in fertilization and later segregate in the formation of gametes, so that the latter are pure with respect to any character, is a familiar part of Mendelian inheritance (Fig. 58). What are these units in terms of

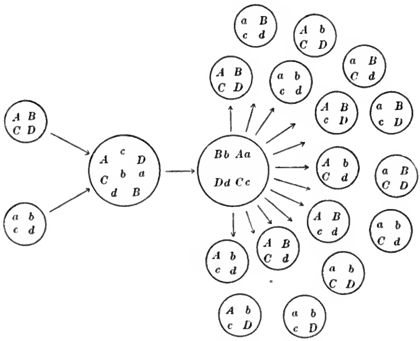

FIG. 58. DIAGRAM SHOWING UNION OF FACTORS IN FERTILIZATION AND THEIR SEGREGATION IN THE FORMATION OF GERM CELLS. With 4 pairs of factors (*Aa*, *Bb*, *Cc*, *Dd*), 16 types of gametes are possible, as shown in the two series of small circles at the right. (From Wilson.)

cell structures and where are they located in the cell? We have in the chromosomes, as Wilson especially has emphasized, an apparatus which fulfils all the requirements of carriers of Mendelian factors (Fig. 59). Both factors and chromosomes come in equal numbers from both parents; both material and paternal factors and chromosomes pair in the zygote and separate in the gamete, as shown in diagrams 58 and 59; and so far as known the chromosomes are the only portion of the germ cells which fulfil these conditions. Furthermore, there is much additional evidence that the chromosomes are especially concerned in heredity, as was pointed out in the last lecture, and it is not reasonable to suppose that this remarkable coincidence between the distribution of Mendelian factors and of chromosomes is without significance.

Of course Mendelian factors are not all the factors of development, but merely the *differential* factors which cause, for example, one guinea-pig to be white and its brother to be black. Very many factors are involved in the production of white or black color, but there is at least one *differential* factor for every unit character, and this alone is the Mendelian factor. Of course there is no such thing as a "sex-producing chromosome," sex being the result of the interaction of the X-chromosome upon other chromosomes, and of all of these upon the cytoplasm. The X-chromosome is only one factor in the determination of sex, but

if it is a factor which differs in the case of the two sexes it is a "sex-determining factor." There are many parts of a germ cell, all of which may be concerned in heredity and development, but the chromosomes appear to be the seat of the differential factors for Mendelian characters.

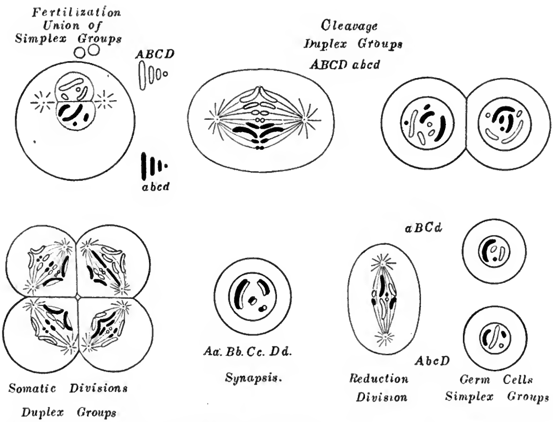

FIG. 59. CELLULAR DIAGRAM CORRESPONDING TO FIG. 58, SHOWING THE UNION OF MATERNAL CHROMOSOMES (*ABCD*) AND PATERNAL ONES (*abcd*) IN FERTILIZATION, their distribution in cleavage, their union into 4 pairs (*Aa*, *Bb*, *Cc*, *Dd*), in synapsis and the separation of the pairs in the reduction division. Only 2 of the 16 possible types of germ cells are shown. (From Wilson.)

2. *Modifications of the Principle of Dominance.*—A great number of animal and plant hybrids show one contrasting character completely dominant over the other one, as Mendel observed in the case of his peas. But in a considerable number of cases this dominance is incomplete or imperfect. When white-flowered strains of four-o'clocks are crossed with red-flowered ones the F_1 plants bear neither white nor red flowers, but pink ones, and the F_2 plants bear white, red and pink flowers. The whites and reds are always homozygous, the pinks heterozygous; pure white and pure red are produced only when their factors are duplex (WW), (RR); when they are simplex (WR) pink is produced. In this case red is not completely dominant over white, but the hybrid is more or less intermediate between the two parents (Fig. 56).

It has long been known that the breed of fowls called Blue Andalusian does not breed true, but in each generation produces a certain number of blacks and whites as well as blues. Bateson found that the blues are really hybrids between blacks and whites in which neither of

the latter is completely dominant. Black and white appear only when they are pure (homozygous), blue only when both black and white are present (heterozygous).

Again, a cross of red and white cattle produces roan offspring, but the latter when interbred give rise to reds, roans and whites in the proportion of 1 : 2 : 1, showing that the roans are heterozygotes in which red is not completely dominant over white, while the reds and whites are homozygotes and consequently breed true.

Lang found that when snails with uniformly colored shells were crossed with snails having bands of color on the shells the hybrids were *faintly banded,* thus being more or less intermediate between the two parents; but when these hybrids were interbred they produced banded, faintly banded and uniformly colored snails in the ratio of 1 : 2 : 1, thus proving that Mendelian segregation takes place in the F_2 generation, and that dominance is incomplete in the heterozygotes. Many other similar cases of incomplete dominance are known.

Sometimes dominance is incomplete in early stages of development, but becomes complete in adult stages. Davenport found that when pure white and pure black Leghorn fowls are crossed the chicks are speckled white and black, but in the adult fowl dominance is complete and the plumage is black. Similar conditions of delayed dominance are well known in the color of the hair and eyes of children, though dominance may become complete when they have reached adult life.

In a few instances a character may be dominant at one time and recessive at another. Thus Davenport found that an extra toe in fowls is dominant under certain circumstances and recessive under others. Tennent found that characters which are usually dominant in hybrid echinoderms may be made recessive if the chemical or physical nature of the sea water is changed. Such cases seem to show that dominance may sometimes depend upon environmental conditions, sometimes upon a particular combination of hereditary units.

Sex and Sex-limited Inheritance

Sex and sex-limited inheritance may be considered here, since they involve questions of dominance. There is good evidence, as was shown in the last lecture, that sex is a Mendelian character, in which the female has a double dose of the determiner for sex, whereas the male has only a single dose. Consequently in the formation of the gametes every egg receives one sex-determiner, while only one half of the spermatozoa receive such a determiner, the other half of them being without it. If, then, an egg is fertilized by a sperm without one of these determiners, a male results; but if an egg is fertilized by a sperm with one of these determiners, a female is produced. This is graphically represented in diagram 60, in which X represents the sex determiner, which is duplex

in the female and simplex in the male, and the chance unions of male and female gametes yield females (XX) and males (XO) in equal numbers.

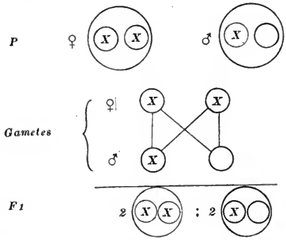

Fig. 60. Diagram Showing Sex as a Mendelian Character, the Female being Homozygous, the Male Heterozygous for Sex. The female forms gametes all of which contain the X-chromosome; the male forms two sorts of gametes one half of which contain the X-chromosome and the other half lack it. All possible combinations of these gametes give a 2 : 2 or 1 : 1 ratio of females to males.

In either sex many secondary sexual characters of the other sex are present during development, and traces of these may persist in the adult; but one set of these characters develops in the male and another in the female, so that they may be called *sex-limited*. The development of the secondary sex characters is usually determined by the ovaries or testes, which are the primary sex characters, though in some instances they may develop in animals which have lost their ovaries or testes, but in the last analysis both primary and secondary sex characters are dependent upon the sex determiner. Sex and sex-limited inheritance are only special cases of Mendelian inheritance in which conditions of dominance differ in the two sexes, depending upon whether the factor for sex is duplex or simplex.

Sex-linked Inheritance

In this connection we may consider another class of characters, which are linked with sex but are in no wise connected with sexual reproduction. Such characters are not necessarily limited to one sex or the other, as are many primary and secondary sexual characters, but they may appear in either sex, though they are usually transmitted from fathers to daughters, or from mothers to sons ("criss-cross" inheritance) in exactly the way in which the sex chromosomes (X) are transmitted. Morgan has therefore concluded that the factors for these characters are carried by the sex chromosomes and has named them *sex-linked* characters. In the fruit fly, *Drosophila,* he has discovered more than twenty-five such characters, applying to the color of the eyes and of the body, to the length of the wings, etc. A typical case is shown in Figs. 61 and 62. The eye color of this fly is normally red, but mutations have arisen in which the eye is white. Such a mutation always appears in males, though it may later be transferred to females, as we shall see. If now a white-eyed male and a red-eyed female are crossed all the F_1s are red eyed, but if these F_1s are interbred all the females of F_2 have

red eyes while half of the males have red eyes and the other half have white eyes (Fig. 61). On the other hand, if one of the F_1 females of this cross is bred with a white-eyed male half of the females of F_2 are

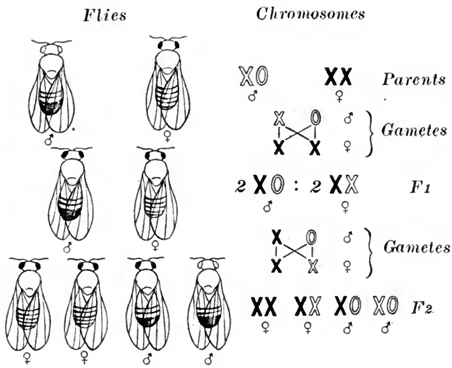

FIG. 61. SEX-LINKED INHERITANCE OF WHITE AND RED EYES IN *Drosophila*. Parents, white-eyed male and red-eyed female; F_1, red-eyed males and females; F_2, red-eyed females and equal numbers of red-eyed and white-eyed males. The distribution of sex chromosomes is shown to right of flies; X carries the factor for red eyes, **X** the factor for white eyes, O stands for absence of X. (After Morgan.)

red eyed and half are white eyed, and half of the males are red eyed and half are white eyed.

If now one of these white-eyed females is bred with a red-eyed male all the females of the F_1 generation are red eyed and all the males white eyed ("criss-cross" inheritance) and if these are interbred there are produced in the F_2 generation equal numbers of red-eyed and white-eyed males and females (Fig. 62).

The distribution of the maternal and paternal sex chromosomes (X) exactly parallels this distribution of this sex-linked character, as is shown in the right half of each of the figures, 61 and 62, and this is certainly very strong evidence that the differential factors for these characters are carried in these chromosomes.

Another case of sex-linked inheritance is found in an abnormal condition in man known as *hæmophilia,* which is characterized by a deficiency in the clotting power of the blood, and consequently by excessive bleeding after injury. "Bleeders" are almost always males, though the defect is always transmitted to a son from his mother, who does not usually show the defect because it appears in females only when both parents were affected. The manner of inheritance of this character is exactly similar to the inheritance of white eyes in *Drosophila* and is in

all probability associated with the distribution of the maternal and paternal sex chromosomes.

One of the most striking cases of sex-linked inheritance is that form of color-blindness known as Daltonism, in which the affected person is unable to distinguish between red and green. It is known that males are more frequently affected than females, and that color-blindness is in some way associated with sex. It requires two determiners for color-blindness, one from the father, the other from the mother, to produce a color-blind female, whereas only a single determiner is necessary to

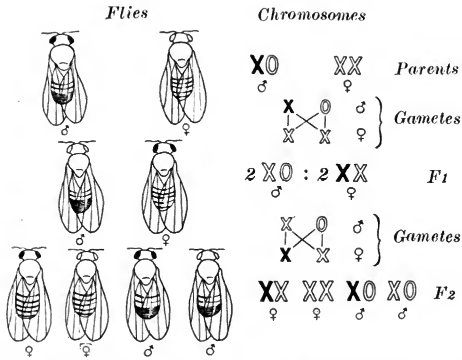

FIG. 62. RECIPROCAL CROSS OF FIG. 61. Parents, white-eyed ♀ and red-eyed ♂, F_1, red-eyed ♀ and white-eyed ♂ ("Criss-cross inheritance"), F_2, equal numbers of red-eyed ♀ and ♂ and white-eyed ♀ and ♂. The distribution of sex chromosomes is shown on the right, as in Fig. 61.

produce a color-blind male, just as is true of sex. The accompanying diagrams illustrate the method of inheritance of color-blindness. As in the previous diagrams **X** represents the sex determiner, O its absence, and X the sex determiner which carries the factor for color-blindness. (Diagrams from Morgan.) It will be seen that a color-blind father and a normal mother have only normal children, but the father transmits to his daughters and not to his sons the sex determiner which carries the factor for color-blindness. But since color-blindness does not develop in females unless it is duplex (*i. e.,* comes from both father and mother), whereas it develops in males if it is simplex (*i. e.,* comes from either parent) all the daughters will appear normal although carrying one determiner for color-blindness, while all the sons will be normal because they carry no determiner for color-blindness. But these daughters transmit to one half of their children the single determiner for color-blindness, and if any of those receiving this determiner are males they will

be color-blind. Consequently we have the curious phenomenon of simplex color-blindness appearing only in males and being transmitted to them only through apparently normal females.

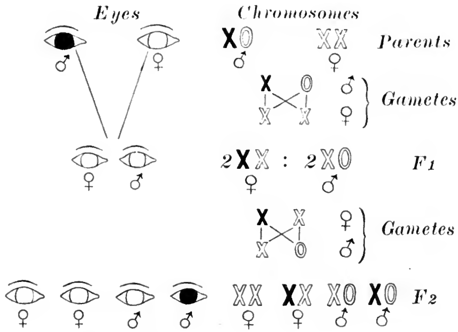

FIG. 63. DIAGRAM OF INHERITANCE OF COLOR-BLINDNESS THROUGH THE MALE
A color-blind male (here black) transmits his defect to his grandsons only. The corresponding distribution of the sex chromosomes is shown on the right, the one carrying the factor for color-blindness being black. (After Morgan.)

On the other hand, if a female is color-blind she has inherited it from both father and mother, *i. e.,* the character in her is duplex, and in all of her children by a normal male the character will be simplex; accordingly, all of her sons will be color-blind and all of her daughters will be normal, though carrying the simplex determiner for color-blindness.

In all cases dominance means merely the development in offspring of certain characters of one parent, while contrasting characters of the other parent remain undeveloped. The appearance of any developed character in an organism depends upon many complicated reactions of germinal units to one another and to the environment. Under certain conditions of the germ or of the environment some characters may develop in hybrids to the exclusion of their opposites, whereas under other conditions these results may be reversed or the characters may be intermediate. The principle of dominance is not a fundamental part of Mendelian inheritance. Even when the characters of hybrids are intermediate between those of their parents, if the parental types reappear in the F_2 generation we may be certain that we are dealing with cases of Mendelian inheritance.

3. *The Principle of Segregation.*—The individuality of inheritance units, and their segregation or separation in the sex cells and recombination in the zygote are fundamental principles of the Mendelian doctrine.

Indeed, the evidence for the individuality and continuity of inheritance units is based entirely upon such segregation and recombination, so that the entire Mendelian theory may be said to rest upon the principle of segregation. If there are cases in which such segregation does not take place they belong to other forms of inheritance than the Mendelian; if segregation occurs in every instance there is no other type of inheritance than that discovered by Mendel. Are there cases which do not segregate according to Mendelian expectation?

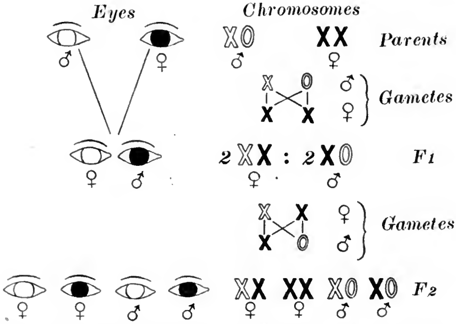

FIG. 64. DIAGRAM OF INHERITANCE OF COLOR-BLINDNESS THROUGH FEMALE. A color-blind female transmits her defect to all her sons, to half of her granddaughters and to half of her grandsons. Corresponding distribution of sex chromosomes on right. (After Morgan.)

When the Mendelian theory was new it was generally supposed that there were forms of inheritance which differed materially from the Mendelian type; indeed, it was supposed that the latter was one of the less common forms of heredity and that blending of parental traits and not segregation was the rule. All cases in which the characters of the parents appeared to blend in the offspring, or in which there was not a clear segregation of the parental types in the F_2 generation or in which the ratio for a monohybrid differed from the well known 3:1 ratio, were supposed to be non-Mendelian.

However, further work has shown that some of these are really Mendelian. Sometimes offspring are intermediate between their parents owing to incompleteness of dominance, rather than to incompleteness of segregation; in such cases the parental types reappear in the F_2 generation as in the cross between red and white four-o'clocks. Sometimes departures from the 3:1 ratio are caused by the fact that two or more factors of the same sort are involved in the production of a single character. Nilsson-Ehle found that when oats with black glumes were

crossed with varieties having white glumes the ratio of 3 white to 1 black was usually found in the second generation; but one variety of black oats when crossed with white gave in the second generation approximately 15 blacks to 1 white, which is the dihybrid ratio. From this and other evidence he concludes that in this variety of oats two hereditarily separable factors are involved in the production of black. In crosses between red-grained and white-grained wheat he usually got in the second generation the monohybrid ratio of 3 red : 1 white, but three strains gave the dihybrid ratio of 15 : 1 and two gave the trihybrid ratio of 63 : 1. Consequently he concludes that while the red color of wheat grains is usually due to one factor for red, it may in some cases be due to two or even three factors; notable departures from expected ratios may thus be explained.

Blending Inheritance

But the most serious objections which can be presented against the universality of the Mendelian doctrine are found in phenomena of "blending" inheritance. In some instances contrasting characters of parents appear to blend in offspring and even in the F_2 in subsequent generations the descendants remain more or less intermediate between the parents. One of the best known illustrations of this is found in the skin color of the mulatto, which is intermediate between the white parent and the black one, and even in the F_2 and in subsequent generations mulattoes do not usually, if ever, produce pure white or pure black children, though the children of mulattoes show considerable variation in color. Here there is an apparent failure of the Mendelian principle of segregation.

But white skin is not really white nor is black skin ever perfectly black. Davenport has shown that there is a mixture of black, yellow and red pigment in both white and black skins, though the amount of each of these pigments varies greatly in negroes and whites. A white person may have a skin color composed of black (b) 8 per cent., yellow (y) 9 per cent., red (r) 50 per cent., and absence of pigment or white (w) 33 per cent. On the other hand a very black negro may have *b* 68 per cent., *y* 2 per cent., *r* 26 per cent., *w* 4 per cent. The nine children of two mulattoes, the father having 13 per cent. of black and the mother 45 per cent., ranged all the way from 46 per cent. to 6 per cent. of black—the latter so far as skin color is concerned being virtually white. On the other hand, where both parents have about the same degree of pigmentation the children are more nearly uniform in color; thus seven children of two mulattoes, the father having 36 per cent. and the mother 30 per cent. of black, ranged only from 27 per cent. of 39 per cent. of black.

Such variations in color in the F_2 and in subsequent generations is

exactly what one would expect in a Mendelian character in which more than one factor is involved, as, for example, in the case of the color of the sweet peas shown in Fig. 59. Davenport, who has made an extended study of this case concludes that "there are two double factors (*AA BB*) for black pigmentation in the full-blooded negro of the west coast of Africa and these are separably inheritable." These factors are lacking in white persons (this being indicated by *aa bb*). Since the germ cells carry only single factors and not double ones, the cross between negro and white would have only one set of these factors for black color, as shown by the formula $AB \times ab = ABab$; hence the color of the F_1 generation is intermediate between that of the two parents. In the F_2 generation there should be a variety of colors ranging all the way from white to black, though pure white or pure black would be expected in only a small proportion of the offspring. As a matter of fact it is known that the children of mulattoes vary considerably in

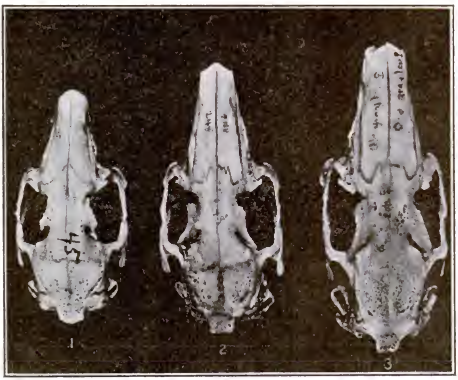

Fig. 65. Blending Inheritance of Size in Rabbits; the skulls of two parents are shown in 1 and 3, of their intermediate offspring in 2. (From Castle.)

color, and in some cases a child may be darker or lighter than either parent, which would indicate that segregation does actually occur. It is very probable that this classical case of "blending" inheritance is really Mendelian inheritance in which several factors for skin color are involved.

Similar blending inheritance is found in certain other cases where the parents differ in form or size. Thus Castle found that when long-eared rabbits were crossed with short-eared ones the offspring have ears of intermediate length, and in all subsequent generations the ear

length remained intermediate between that of the parents. He found the same thing true of length and breadth of the skull (Fig. 65) and of the size of other portions of the skeleton, and he concluded that such quantitative characters are not inherited in Mendelian fashion.

Quite recently MacDowell, working on the inheritance of size in rabbits, concludes that this, as well as other quantitative differences between parents which appear to blend in the offspring, such as Castle's case of ear length in rabbits, is due not to a single factor, as in the case of Mendel's tall and dwarf peas, but to several factors. Consequently, in the formation of the germ cells there is not a clear segregation of all the factors for tallness, or large size or long ears, in half the germ cells, and their total absence in the other half of those cells, but some of these factors go into certain cells and others into others, as in the case of dihybrids, trihybrids or polyhybrids. As a result offspring appear more or less intermediate in size between their parents.

Thus it is possible to explain even "blending" inheritance as due not to the real fusion or blending of inheritance factors, but to varying combinations of numerous or multiple factors, according to the Mendelian rules. The Mendelian principle of segregation has been found to be of such general occurrence that there is a strong inclination among Mendelians of the stricter sort to make it universal, and to explain all cases of blending inheritance as due to incomplete dominance and to multiple factors. Whether or not such attempts may prove completely successful it is still too soon to say.

III. Mendelian Inheritance in Man

The study of human inheritance must always be less satisfactory and conclusions less secure than in the study of lower animals for the following reasons: In the first place there are no "pure lines," but the most complicated intermixture of different lines. In the second place experiments are out of the question and one must rely upon observation and statistics. There have been less than 60 generations of men since the beginning of the Christian era, whereas Jennings gets as many generations of *Paramecium* within two months and Morgan almost as many generations of *Drosophila* within two years. Finally the number of offspring are so few in man that it is difficult to determine what all the hereditary possibilities of a family may be. Bearing in mind these serious handicaps to an exact study of inheritance, it is not surprising that the method of inheritance of many human characters is still uncertain.

Davenport and Plate have catalogued more than sixty human traits which seem to be inherited in Mendelian fashion. About fifty of these represent pathological or teratological conditions, while only a relatively small number are normal characters. This does not signify that the

method of inheritance differs in the case of normal and abnormal characters, but rather that abnormal characters are more striking, more easily followed from generation to generation, and consequently statistics are more complete with regard to them than in the case of normal characters. In many cases statistics are not sufficiently complete to determine with certainty whether the character in question is dominant or recessive, and it must be understood that in some instances the classification in this respect is tentative. A partial list of these characters is given herewith:

Mendelian Inheritance in Man

NORMAL CHARACTERS

Dominant	*Recessive*
Hair:	
Curly.	Straight.
Dark.	Light to red.
Eye Color:	
Brown.	Blue.
Skin Color:	
Dark.	Light.
Normal pigmentation.	Albinism.
Countenance:	
Hapsburg type (thick lower lip and prominent chin).	Normal.
German type.	Jewish type.
Temperament:	
Nervous.	Phlegmatic.
Intellectual Capacity:	
Average.	Very great.
Average.	Very small.

TERATOLOGICAL AND PATHOLOGICAL CHARACTERS

General Size:	
Achondroplasy (dwarfs with short stout limbs but with bodies and heads of normal size).	Normal.
Normal size.	True Dwarfs (with all parts of the body reduced in proportion).
Hands and Feet:	
Brachydactyly (short fingers and toes).	Normal.
Syndactyly (webbed fingers and toes).	Normal.
Polydactyly (supernumerary digits).	Normal.
Skin:	
Keratosis (thickening of epidermis).	Normal.
Epidermolysis (excessive formation of blisters).	Normal.

Hypotrichosis (hairlessness associated with lack of teeth).	Normal.
Kidneys:	
Diabetes insipidus.	Normal.
Diabetes mellitus.	Normal.
Normal.	Alkaptonuria (urine dark after oxidation).
Nervous System:	
Normal condition.	General neuropathy, *e. g.*,
	Hereditary epilepsy.
	Hereditary feeble-mindedness.
	Hereditary insanity.
	Hereditary alcoholism.
	Hereditary criminality.
	Hereditary hysteria.
Normal.	Multiple sclerosis (diffuse degeneration of nerve tissue).
Normal.	Friedrich's disease (degeneration of upper part of spinal cord).
Normal.	Meniere's disease (dizziness and roaring in ears).
Normal.	Chorea (St. Vitus dance).
Huntington's chorea.	Normal
Muscular atrophy.	Normal
Normal.	Thomsen's disease (lack of muscular tone).
Eyes:	
Hereditary cataract.	Normal.
Pigmentary degeneration of retina.	Normal.
Glaucoma (internal pressure and swelling of eyeball).	Normal.
Coloboma (open suture in iris).	Normal.
Displaced lens.	Normal.
Ears:	
Normal.	Deaf-mutism.
Normal.	Otosclerosis (thickened tympanum with hardness of hearing).

SEX-LINKED CHARACTERS

Recessive characters, appearing in male when simplex, in female only when duplex.

Normal.	Gower's muscular atrophy.
Normal.	Hæmophilia (slow clotting of blood).
Normal.	Color-blindness (Daltonism; inability to distinguish red from green).
Normal.	Night blindness (inability to see by faint light).
Normal.	Neuritis optica (progressive atrophy of optic nerve).

Summary

The principles of heredity established by Mendel are almost as important for biology as the atomic theory of Dalton is for chemistry. By means of these principles particular dissociations and recombinations of characters can be made with almost the same certainty as particular dissociations and recombinations of atoms can be made in chemical reactions. By means of these principles the hereditary constitution of organisms can be analyzed and the real resemblances and differences of various organisms determined. By means of these principles the once mysterious and apparently capricious phenomena of prepotency, atavism and reversion, find a satisfactory explanation.

Before the establishment of Mendel's principles, heredity was, as Balzac said, "a maze in which science loses itself." Much still remains to be discovered about inheritance, but the principles of Mendel have served as an Ariadne thread to guide science through this maze of apparent contradictions and exceptions in which it was formerly lost.

RUBBER: WILD, PLANTATION AND SYNTHETIC

By Dr. JOHN WADDELL
SCHOOL OF MINING, QUEEN'S UNIVERSITY

AN industry can not be wholly uninteresting which involves the consumption yearly of about $250,000,000 worth of raw material in the production of goods worth $750,000,000 which has grown to nearly double its size in seven years, which involves the cultivation of three quarters of a million acres or more of land, worth about $130 an acre, but half of which has during a boom been capitalized at double its value, an industry whose center will be speedily shifted from the banks of the Amazon, half way round the world, to Ceylon and the Malay States, unless very heroic measures are taken to prevent it, among which heroic measures the importation of 50,000 Chinese coolies into the Amazon valley has been suggested.

Such is the rubber industry. When it is added that the price, which for a number of years had been a little above a dollar a pound, went up during 1910 to over three dollars and last September fell as low as fifty cents; and that in connection with the rubber trade there have been some of the most sensational stories of inhumanity and barbarity in the Congo district and on the upper Amazon, it will be seen that the economist and the social reformer must be specially interested.

There are, too, features of interest for the botanist, since rubber is got from plants and its function in the plant is obscure. Moreover, there are notable peculiarities in its extraction which offer opportunities for further research. The chemist is interested not only from the point of view of the conversion of the raw product into a material suitable for the many purposes to which it is applied, but also from the fact that he sees here one more opportunity to replace the work of nature and to do in a small laboratory covering only a few acres what now requires thousands of square miles.

A book appeared in Spain early in the seventeenth century (1601–15) describing the voyages of the Castillians, from 1492–1554, in which a game played by the natives of Hayti with balls made from the gum of a tree was mentioned. About the same time Juan de Torquemada described a rubber tree of Mexico, the *Castilloa elastica,* and stated that the Indians used the rubber for medicinal purposes and that the Spaniard used it for waterproofing coats. Rubber trees of various kinds were soon discovered in Brazil, French Guiana, Madagascar and other places.

Chemists attempted to find industrial uses for the product of the rubber tree, and it may be added that the search in the future is likely

to be more vigorous than it has ever been in the past. The difficulty of discovering a good solvent baffled chemists for a time, but in 1761 Herissant and Macquer used oil of turpentine and said that ether might also be employed. The name rubber seems to date from Priestley's discovery in 1770 of its power to erase pencil marks, the name caoutchouc being apparently a modification of the Indian name cahucha. In Priestley's time rubber could not be considered a plentiful article of commerce, its price being twenty shillings an ounce.

Though patents for the use of rubber as waterproofing had been taken out as early as 1791, Macintosh in 1823 seems to have been the first to make the industry a commercial success and the firm then started in Glasgow and afterwards removed to Manchester remains to this day as one of the most important in the rubber industry.

The next important step was taken by Hancock in England and Goodyear in America about 1840, the date being a little inexact because the process seems to have been in use before being patented. This was the addition of sulphur to rubber by which it is made capable of standing the hottest summer temperature without becoming sticky or losing its elasticity.

It was not till about 1886 that a process was discovered for depriving rubber of the smell which restricted its use for waterproofing. The rubber industry received an impetus when pneumatic tires came into use for bicycles, and the employment of rubber as an insulator in electric installations also increased the demand, but the dominating factor in the consumption of rubber has of late years been the automobile business. The very sudden demand in 1910 caused a tremendous rise in prices, and whereas during a portion of 1909 the price in London was 2s. 9d. in 1910 it reached 12s. 6d.

The growth of the rubber industry is indicated by the following figures. Import of crude rubber into Great Britain was in

1830	23 tons
1850	381 "
1870	7,656 "
1910	43,848 "

The rubber plant grown in houses for ornamental purposes is usually *Ficus elastica,* which is native mainly to southern Asia. This is not the plant chiefly used for the production of rubber. Four different orders of plants provide commercial rubber and there are eleven genera belonging to these given in Thorpe's "Dictionary of Applied Chemistry." By far the most important is *Hevea brasiliensis* which provides the "fine Para" rubber of South America the standard of rubber in the trade. To the same order, Euphorbiaceae, belongs *Manihot Glaziovii* also found in a small section of Brazil. It produces the Ceara rubber of commerce.

Another interesting source of rubber is the genus *Landolphia,* of which there are several species noteworthy as being creepers. This genus provides most of the Congo rubber and belongs to the order Apocynaceae. *Ficus elastica* spoken of above is one of the genera of the order Urticaceae of which another genus is *Castilloa* also already mentioned as found in Mexico and one of the very first plants to attract attention as a rubber producer.

Rubber, though found to a slight extent as a solid deposit in the woody fiber of certain species, is almost entirely obtained from the latex of the rubber-bearing plants. The latex is a fluid usually more or less viscous which is carried in vessels, the laticiferous vessels, lying in the inner bark just a little outside of the cells which carry the sap. The caoutchouc itself is in globules of microscopic or sub-microscopic size, being from 1/50,000 inch to 1/6,000 inch in diameter, and forms an emulsion with the suspending liquid. A familiar example of latex is the exudation of the milkweed. The function of latex in the plant itself is unknown. It may be an excretion, it may be intended for the preservation of the tree from attack by fungus or insects or other enemy. The process of raw rubber manufacture consists in the collection of the latex and the coagulation from the serum of the emulsified particles. In tapping the trees the essential thing is to cut deep enough into the bark to sever the laticiferous vessels, but not to cut into the cambium, the living layer of cells from which both the wood and the bark of the tree are produced. In the Amazon Valley this is usually done by a small axe, the incisions being of a V shape, the first being made at a height of about six or seven feet. Later incisions are made at intervals of about two inches below the previous ones, till the base of the tree is reached. Then tappings are begun on the other side of the tree in the same order as before. The latex is collected in a small cup fixed to the tree by moist clay and is removed from time to time. Five pounds of latex is considered a large amount from one tree during the season. The latex is gathered from the cups into a pail and is cured by the smoke of a fire rich in tarry and acid matter. A long wooden rod has rubber latex poured over it and the thin layer which sticks to the rod is dried in the smoke. Over the sheet thus formed is poured more latex, which is also dried in the smoke. Thus layer after layer is produced till a ball weighing from twenty to one hundred pounds is obtained. Thus is made raw fine Para rubber. Some of the latex coagulates on the tree, forming a scrap rubber which is collected and compressed into irregular masses called "negroheads."

It is not my purpose to describe all the processes through which raw rubber passes before it appears in the shape of golf balls or automobile tires or in any of the many forms in which it comes into commerce, but a very brief outline may be given. First, the raw rubber is cut into

small pieces, steeped in warm water and run through washing rolls, after which it is dried. Rubber thus obtained is mainly a hydrocarbon of the empirical formula C_5H_8, that is, it contains sixty parts by weight of carbon to eight of hydrogen. There is a small amount of resin, a very little protein and somewhat less than one per cent. of inorganic matter which forms an ash when the rubber is burned.

Freshly coagulated rubber has a spongy or reticular structure, due to the way in which the particles come together. This shows even in dried rubber and the particles can still be seen in globular form after solution, but films made by the evaporation of the solvent from the solution have apparently lost the reticular character. Rubber on being heated becomes sticky and if cooled to near the freezing point of water (about 40° Fahr.) it becomes hard and loses its elasticity. Stretched rubber has the very peculiar property of contracting on being heated. This curious property was predicted from theoretical considerations and was later confirmed by experiment. A suitable way to carry out the experiment is to stretch a rubber tube to nearly double its length by means of a heavy weight and then to pass steam through the tube. A tube a couple of feet in length will under these circumstances contract several inches.

Pine rubber softens too readily with rise of temperature and hardens before the temperature has fallen much below normal; the range of temperature through which it retains its properties of toughness and elasticity is too limited, but by the addition of sulphur the range of temperature can be very much extended. Rubber can be made to take up sulphur in various ways, the process being called "vulcanization." One method is by heating with sulphur, another is by treatment in the cold with a mixture of chloride of sulphur and carbon bisulphide. The properties of vulcanized rubber vary with the amount of sulphur, soft rubbers contain 3–4 per cent., while hard rubber, or ebonite, contains 20–30 per cent. The sulphur seems to be combined in some form, at least partially with the rubber. No matter how much sulphur may be mixed with the rubber or what the temperature or length of time, the maximum of combined sulphur is about thirty-two per cent.

The main source of rubber supply, almost up to the present, has been the wild-growing trees and vines. In 1906 about 400 tons (approximately one per cent. of the whole) were obtained from plantations, by 1909–10 the amount had risen to about five per cent.; now plantation rubber has almost overtaken that derived from uncultivated plants. Java produced 73 tons in 1910 and 491 tons in 1911, while, during the first three months of 1912, the Malay States produced 3,810 tons, and during the corresponding three months of 1913 the amount was 5,625 tons, or over a half more. The rapid increase is due to the fact that each year more and more of the trees are reaching the productive age.

In 1876, some seeds of *Hevea brasiliensis* were sent from Brazil to Kew Gardens, and some young plants from these seeds were shipped the same year to Ceylon, where they were planted in low land and the grove then started is now historic, for it was the beginning of the later industry. Up till 1899 there were only about 750 acres of rubber plantation in Ceylon and these were apparently not intended for commercial purposes. In 1899 the first company in the Malay States was formed and it declared a dividend of 75 per cent. in 1908, and owing to the high prices or rubber in 1909 the dividend was 250 per cent.

The large amount of rubber required for automobile tires naturally stimulated the planting of rubber areas. According to figures given in a U. S. Consular Report in January, 1913, the acreage in Ceylon in 1912 was 220,000 and in the Malay States 430,000, while in other countries over 100,000 acres were under cultivation. Figures given later in the year by *The Economist* were higher. The larger part of this area is not yet productive, and some of it will not yield for five or six years.

The source of cultivated rubber is almost entirely *Hevea brasiliensis,* which seems to be adapted to wide differences of conditions. In Ceylon, though first planted in low land, it grows on hills with large boulders, in the Malay district it thrives on flat land with hardly a stone. On the Malay hills, where heavy rains would carry away the young trees, contour drains are constructed. The genus *Castilloa* does not grow so readily in the East; it takes longer to reach the producing stage and it does not produce so much rubber when it has attained its proper growth. It has, however, been largely planted in its original home, Mexico. *Manihot-Glaziovii* is planted in dry regions, where *Hevea* does not flourish.

Hevea is not fit for tapping till it is seven years old. As the seven or eight feet nearest the bottom of the trunk are richest in latex, the object in cultivation is to produce short trunks of large circumference. With this end in view, the trees are planted far apart, at a distance of about twenty feet from each other, giving approximately a hundred trees to the acre. They are induced to fork at a height of about ten feet, and it is said that the best arrangement is a tripartite forking of the main trunk, each branch in turn forming three subordinate branches. In places where there are high winds, however, this style of forking may provide so large a surface that the trees may be blown over.

There are various methods of tapping, the most satisfactory apparently being full or half "herring bone." A vertical groove is made in the bark of the tree from the base to a height of five or six feet. Then parallel incisions are made from this vertical groove in an upward slanting direction, in the case of the half-herring bone, on one side, and in the case of the full herring bone, on both sides. So important is it to cut through the laticiferous vessels without injuring the cambium layer and so difficult is it to accomplish this kind of incision, that dozens of

different knives have been invented for the purpose. The half-herring bone method is considered the better as being less severe on the tree.

A very curious phenomenon was observed in the early experiments on tapping. It was found that if a second incision was made in the bark of *Hevea,* near one cut a couple of days previously, there was a greater flow of latex than if the second incision were made at a distance, say, on the other side of the tree. More than that, the latex flowed more freely than on the first incision. In a particular experiment on four trees, tappings were made at intervals of five days, and the volume of latex increased from 61 c.c. at the first tapping to 449 c.c. at the fourteenth, when the series was ended. In view of the fact that the latex from later tappings is thinner than that from the first, another series of experiments was made on ten trees which were tapped every day for a fortnight and the rubber content of each tapping determined. This rose from 6¼ oz. on the first day to 33¾ oz. on the fourteenth. Within limits a thin latex is the most satisfactory, the latex from the first incision often being of little use because it coagulates before reaching the proper receptacle and so gets mixed with the bark of the tree and other foreign matter. Sometimes drip pans are fastened to the tree above the incisions, and water dropping upon the incisions prevents the latex drying on the tree.

The peculiar action of *Hevea* owing to which subsequent tappings near the previous incisions produce a greater flow of latex is called "wound response," and no other rubber-bearing plants show wound response in anything like the degree shown by *Hevea*; in fact, it may be doubted whether the phenomenon occurs in the other genera at all. As compared with *Hevea, Castilloa* gives a greater flow of latex on the first incision, some five or six times as much. But if, after a couple of days, a further incision is made near the former one, little or no latex flows from it, while, as we have seen, there is in the case of *Hevea* a greater supply than before, roughly about twice as much, which persists through subsequent tappings. Accordingly, in tapping trees a very thin paring (about one twentieth of an inch) is removed each day or each alternate day. As the first incisions are made about a foot apart, it takes some two hundred and forty parings before the bark is all removed from this part of the tree, and as by the half-herring-bone system only about a quarter of the tree is tapped it takes about four years to remove all the bark and by that time operations can be begun again on the new bark that has formed in the meantime.

The arrangement of laticiferous vessels in *Castilloa* is different from that in *Hevea*; in the former the vessels all connect in a somewhat similar manner to that of veins and arteries in the body. Hence, when the vessels are cut, there is likely to be a drain from a large area. In *Hevea* the tubes arise from a breaking down of cell walls which occur from time to time and so the latex does not flow out so freely at first. Possi-

bly, the increased flow when the second incision is made near the first is because latex has flowed to the wound in order to repair it.

Though *Hevea* seems to be in general the best rubber-producing tree, there is a little doubt whether it should be everywhere introduced; for instance, in Africa, where another species is native. African labor is less intelligent than that in the Malay States and the African natives can not tap the trees so successfully. The native trees and vines are usually cut down.

Moreover, experiments should be made with plantations of from three to five thousand trees before a decisive judgment is given, for it is possible that in large plantations diseases might rise and spread which have not appeared in small plantations. In very large estates, protective belts of other trees either of the original forest or of *another genus* of planted rubber should be made use of to prevent spread of diseases.

While, as stated above, in the Amazon valley five pounds of latex containing approximately two pounds of caoutchouc is considered a large yield, on the plantations trees ten years old are expected to yield three or four pounds of rubber. During 1908 nine thousand trees in the Cicely estate, one of the older Malay companies, gave an average of six pounds per tree, though the trees were between five and ten years old. In the Perah State there were eight trees seventeen years old, of an average girth of 55 inches, which yielded 28½ pounds of rubber each. From the economic point of view the yield per acre is of more importance than the yield per tree. Six-year-old trees will yield about a hundred pounds per acre, while ten-year-old trees will yield three or four times as much.

In the East, rubber is coagulated from the latex by acetic acid. Smaller quantities of other acids would serve the same purpose, but an excess prevents coagulation, while with acetic acid the quantity may vary within fairly wide limits. When coagulation is brought about by acetic acid either pains must be taken to dry the rubber very thoroughly or some antiseptic must be put in. The method of smoking carried out in the Amazon district provides both acetic acid and the antiseptic fumes of creosote. Coagulation could be brought about by simple drying, but in this case the rubber is apt to become moldy and putrid. The precise cause of coagulation by acid is not certain. It has been ascribed to the small amount of protein in the latex, but, on the other hand, it is claimed that if the protein is removed the rubber can still be coagulated. The rubber produced has a composition something like the following: 94 per cent. caoutchouc, 3 per cent. resin, 2.5 per cent. protein, and 0.5 per cent. each of moisture and ash. One should perhaps add that what is usually called protein may not really be that substance, but some other which contains nitrogen.

The competition between Amazon hard Para rubber, which is so far the standard, and plantation rubber is keen. The latter is the purer, but

the conditions for vulcanizing and otherwise treating Para rubber are better known and rubber manufacturers will probably agree with the opinion expressed to me by one of them that plantation rubber is not so easily worked. Para rubber is said to be harder and "nervier" in the mixing rolls and is more consistent in quality. What causes the difference is unknown; whether the immaturity of the plantation trees, or the method of curing or some other factors. The difference is exhibited not only in the ways indicated, but also by the action of some chemical reagents. In a series of experiments, the part of Para rubber soluble in petroleum ether was in one sample 51 per cent., in another 57 per cent., while of Ceylon biscuit 58 per cent. and 68 per cent. were soluble, and of Malayan crêpe 72 per cent. and 86 per cent. The part dissolved from the Para rubber was much more viscous than that from the other kinds.

The price of plantation rubber in the London market is lower than that of Para rubber, but this is probably due, at least partly, to the method of sale by auction. According to *The Economist,* during the first eight months of 1913, Para averaged 3s. $10\frac{1}{4}$d. while plantation rubber averaged 3s. $5\frac{1}{4}$d. and, curiously enough, when plantation rubber dropped in September to 2s. a pound, Para was 3s. 7d.

Though up to the present plantation rubber is not equal in quality to the best Para rubber, it will be remembered that a considerable quantity of the rubber from the Amazon district itself is not of the highest grade. One quarter or more is of inferior quality. The price in general has dropped till it leaves little margin above the cost of production. While the export from the Amazon district has increased little, if any, since 1909, being in the neighborhood of 42,000 tons, plantation rubber, which in 1909 was 4,000, amounted in 1912 to 30,000 tons. The total rubber consumption in 1912 was about 108,000 tons, part of it being wild rubber from Mexico and various places in Africa, part being old rubber reclaimed. In the season 1912–13, according to the U. S. Consular Reports, the Amazon district exported 2,200 tons more than in the previous season, but the same reports predicted a decrease in the season 1913–14 and, according to the *Journal of Commerce,* during July, August and September, the first three months of the 1913–14 season, the export was 7,161 tons as compared with 8,553 tons of the year before. The statement is made in the Consular Reports that this year for the first time other countries will produce a greater amount of plantation rubber than the Amazon Valley of wild rubber.

Mr. Akers, a British rubber expert, estimates that in 1916 plantations could yield 173,000 tons and in 1919, about 300,000 tons. He also estimates that if rubber falls to two shillings a pound 150,000 tons or perhaps 200,000 tons might be consumed for the present uses, but unless new uses not now apparent are discovered the supply will much exceed the demand.

At present the cost of production of Para rubber is 72 cents, including the export tax, which amounts to 24 cents. This high cost is partly due to the cost of living, partly to difficult transportation, partly to scarce labor and inefficient methods of gathering the rubber. Mr. Akers recommends the importation of 50,000 Chinese coolies, the employment of a number of Malayan planters to instruct the collectors in the best methods of tapping, and the abolition or, at all events, reduction of the export tax. The Brazilian government has given a large sum of money to improve navigation on the Amazon and to provide premiums for the construction of rubber factories and refineries, engaging to buy from these refineries all the rubber required for the army and navy. They doubtless feel chary about reducing the export tax, as it is a great, if not even the greatest, source of revenue.

The future of the rubber industry causes anxiety not only to the Amazon district and those interested in it, but to the thousands of stockholders in eastern plantations. The great demand for rubber for automobile tires caused a boom and, according to *The Economist*, £40,000,000 was invested in boom prices "whose only justification is the few years of grace before the supply surpasses the demand." On September 20, last, the same paper remarks:

> The collapse of the rubber boom is one cause for the lack of business in the Stock Exchange. Hundreds of thousands of pounds poured into the plantation rubber industry by the British public are represented by huge stocks of certificates, the depreciation on which, reckoned from the price at which the public got them, will serve as a painful lesson till the next boom, from whatever quarter it may spring up, comes along.

A large meeting of the leading people in the rubber world was held in London on October 23, and stocks went up just before the meeting, only to fall when it was learned that no solution of the difficulty could be found. The cost of bringing an estate into bearing condition is between twenty and thirty pounds an acre, and *The Economist* estimates over seven hundred thousand acres in the East capitalized at from £54 to £76 an acre.

It will not pay to produce rubber to sell in the world's markets at two shillings a pound, unless the cost of production can be reduced. In some very favored estates, in Ceylon, the cost is only sixpence a pound and, when all the trees are yielding, the average cost may be 8d, though in 1911 it was 1s. 4d. Mr. Akers considers that in Java the cost will not go below 1s. 2d. for several years. In Ceylon labor is more easily obtainable than in the Malay States and Java. In the Malay States a good deal of the labor is done by coolies from southern India along with some Chinese. An economic question arising here is the relative value of indentured and unindentured labor.

The artificial production of rubber is not yet a matter of commercial

interest. Dr. Gerlach, of Hanover, a practical manufacturer, thinks it may be twenty years before artificial, or, as it is sometimes called, synthetic rubber can compete with the natural. He points to the fact that it took at least as long a time for synthetic indigo to reach the commercial stage after it had been first produced in the laboratory. Millions of dollars were expended in the investigations by one firm alone. But as we have had the romance of the alizarine industry, by which a product of coal tar replaced the extract of the madder root and ended its cultivation in France, and the romance of the indigo industry which has so largely affected the growth of the indigo plant in India, so we may have the romance of the synthetic rubber industry, but many a long and weary investigation must be carried on, many patents will be abandoned and much money will be spent, apparently in vain, for no process can be considered commercial unless it can produce rubber not only more cheaply than it can now be obtained from the plantations, but more cheaply than there is any likelihood of its ever being produced from natural sources. Probably twenty cents a pound should be considered the maximum cost of a commercial process for synthetic rubber.

Rubber was found to yield on heating the substance isoprene among others. This substance has the same percentage composition as rubber, but its molecular structure is considered to be simpler and to be represented by the formula

$$CH_2 = \underset{\displaystyle CH_3}{\overset{|}{C}} - CH = CH_2$$

Isoprene was accidentally found to change into rubber apparently upon long standing, and efforts were made to produce rubber from isoprene at will. It was found that by heating at a high temperature with acetic acid in closed tubes the change takes place and later a small amount of sodium was found to produce a similar effect at a lower temperature.

The problem of synthetic rubber is then two-fold: first, to get cheap isoprene; second, to convert isoprene cheaply into rubber. The most natural source of isoprene seems to be oil of turpentine, which has the same percentage composition, but it has not proved satisfactory and its formation from isoamyl alcohol gives greater promise. Isoamyl alcohol is one constituent in fusel oil, whose presence in raw spirits renders them so injurious. It is obtained to a small extent in the ordinary fermentation of potatoes and other starchy substances. Professor Fernbach, of the Pasteur Institute, has discovered a method of fermenting starch which, instead of yielding a large amount of ordinary alcohol and a small amount of fusel oil, produces fusel oil with practically no ordinary alcohol. This fusel oil, however, instead of having a large quantity of isoamyl alcohol consists chiefly of butyl alcohol, from which butadiene,

$CH_2 = CH - CH = CH_2$, can be made in just the same way as isoprene from isoamyl alcohol. Butadiene is the next lower homologue of isoprene, and when it is treated with sodium it produces a substance very like rubber which is called nor-caoutchouc. It is said that its quality is even superior to that of ordinary rubber. As there are a number of alcohols homologous to butyl and isoamyl alcohol, a number of substances similar to isoprene and butadiene can be made from them, and from these by the action of sodium a *series* of rubbers. It is said that the rubber produced by the action of acetic acid on isoprene is identical with natural rubber, and that the rubber made by the action of sodium is slightly different in its chemical reactions. It may be that all natural rubbers are not identical and that the difference between Para rubber and plantation rubber may depend upon some slight differences in the caoutchouc itself and that what the chemist does with extreme difficulty when he changes starch into rubber, nature does with ease, and, as the chemist may get slightly different products by pursuing different methods, so nature may get different products under different circumstances.

It was said at the beginning of this paper that rubber has the empirical formula C_5H_8. It seems that the formula is more correctly written $C_{10}H_{16}$ and that the name 1.5 dimethyl cyclooctadiene 1.5 represents the structure of Para rubber, while the rubber produced by the action of sodium on isoprene is

1.5 dimethyl cyclooctadiene 1.3
or 1.5 dimethyl cyclooctadiene 1.7

Dr. Duisberg, of Elberfeld, stated in his address to the Congress of Applied Chemistry at New York in 1912 that he had for some time used tires of artificial rubber on an automobile. The German Emperor has also received a present of similar tires. The rubber can be made, but it is still far too expensive to compete with natural rubber.

Closely connected with the history of the rubber industry are the Congo atrocities. Congo rubber is not so good for most purposes and commands a lower price, though, being softer, it is said to be better as a filling for driving belts and for other uses. It is obtained from *Landolphia* vines, which are not usually tapped, but cut off, the latex being extracted all at once. This fact may be partly responsible for the atrocities, since, the more accessible sources of supply having been depleted, the natives have been obliged to go farther and farther in order to obtain the rubber demanded of them.

In the sixties and seventies of the last century, central Africa became known to Europe, and the commercial interests of the various nations led to what is termed the "Scramble for Africa." Stanley's discovery of the Upper Congo induced King Leopold to form the "International African Association" and he sent several investigating expeditions at

his own expense, commanded for the most part by Englishmen and Germans and represented to the world as being entirely for scientific purposes. Later Leopold proposed forming the association into a state and obtained the sympathy and support of the British Chambers of Commerce by promising perfect freedom of trade, and of the protestant missionary societies of England and America, of the aborigines' protection association, and of the philanthropic world in general by his protestations of the highest type of philanthropy.

Several years before that time, Sir Robert Morier suggested to Lord Beaconsfield to recognize the claims of Portugal to the southern bank of the Congo, while the northern bank was to become British. Lord Beaconsfield, however, did not favor this plan, and when, in 1875, the consul Lieutenant Cameron proclaimed, on his own initiative, the taking possession of the basin of the Congo, his act was repudiated by Lord Carnarvon. Portugal and England had historic claims on the country, and the two governments made an agreement in 1883 by which Portugal was to gain the basin of the Congo on both sides for a certain limited distance from the mouth, engaging to give freedom of trade to the world and religious freedom to all inhabitants of the country. The treaty was denounced by the British Chambers of Commerce and the British philanthropic world. The British government was accused of betraying national interests, and in Portugal the Portuguese government was accused of the same thing. France was ready to step in and take the district, in which case foreign trade would be handicapped. King Leopold seized the opportunity, and Stanley, acting on his behalf, renewed the advances made before to England. The English government was now more ready to listen to the proposal, but, being anxious to secure freedom of trade and protection of the natives, fell in with the invitation of Bismarck to an international conference at Berlin. This conference was held from November 25, 1884, to February 26, 1885, and guaranteed the formation of the Congo association into a state. The representatives of the different powers may be almost said to have wept for joy at having found so disinterested and philanthropic a ruler for the state as King Leopold promised to be. On August 1, Leopold notified the powers that the International African Association would henceforth be known as the Congo Free State.

King Leopold began to form an army, and by 1889 two thousand regulars had been recruited and were armed with modern rifles, and the proposal for the next year was to raise eight thousand more. The King's officials were given a bonus for each recruit obtained, and these recruits were gathered by armed raids on the villages.

In 1891 a regulation was issued forbidding the natives to sell ivory and rubber (the main products of the country) to European merchants, and the officials were given a bonus for the amount of rubber supplied

by them, the rubber becoming the property of the state and the bonus being the greater the less the cost of the rubber. A similar bonus was given on ivory and gum copal. This was a direct stimulus towards extortion on the part of the officials. Villages were taxed for a certain amount of rubber, and if it was not forthcoming punishments of all kinds were inflicted, a common one being the cutting off of hands, another, the carrying off of the women as hostages.

Such a feeling was aroused in Europe by reports from missionaries and others of the atrocities, that King Leopold was compelled to appoint a commission of enquiry, which reported in 1905 or early 1906. This report tells that the native peoples are "exhausted" through the demand made upon them for headcarriage in the transport of government material and that they are threatened with partial destruction. Captain Baccari, envoy of the King of Italy, traveled through that region and says, "we have all the ghastly scenes of the slave trade, the collar, the lash, and the pressgang." A lieutenant in the Italian army who spent three years in the Congo Free State and served in Leopold's African army writes:

> The caravan road between Kasongo and Tanganyika is strewn with corpses of carriers, exactly as in the time of the Arab slave trade. The carriers, weakened, ill, insufficiently fed, fall literally by hundreds; and, in the evening, when there happens to be a little wind, the odor of bodies in decomposition is everywhere noticeable, to such an extent, indeed, that the Italian officiers have given it a name ''Manyema perfume.''

The commission reports that the direct causes of the miseries of the natives are the requisitions in rubber and the requisitions in staple food supplies "everywhere on the Congo, and, notwithstanding certain appearances to the contrary, the native gathers india rubber only under the influence of direct or indirect force." It indicates what is meant by force, namely, indiscriminate massacre, settlement of soldiers in rubber-producing villages, uncontrolled and unhampered in the execution of their instructions, taking of hostages, imprisonment of women and children, flogging, illegal fines and punishments and so on. The condition of the rubber gatherer is described:

> In the majority of cases he must, every fortnight, go one or two days' journey and sometimes more, to reach the place in the forest where he can find in fair abundance the rubber vine. There the gatherer passes some days in a miserable existence. He must construct an improvised shelter which can not obviously replace his hut; he has not the food to which he is accustomed; he is deprived of his wife, exposed to the inclemencies of the weather and to the attacks of wild beasts. He must take his harvest to the station of the government or the company, and it is only after that that he returns to his village, where he can barely reside two or three days before a new demand is made upon him.

This is taken from the report of King Leopold's own commission, which naturally does not overstate the case. I could easily have quoted

a much more lurid description of the facts. I shall merely add one sentence from Professor Cattier's famous volume upon the Congo which was discussed in the Belgian House of Representatives, along with the Report of the Commission. He says:

> The impositions in rubber and foodstuffs which weigh upon more than half the territory, that is to say, over an area three or four times as large as France, subject the natives to a well-nigh-continuous slavery, a slavery more severe than that imposed by the Arabs.

In 1908 the Congo was made over by King Leopold to Belgium, and the transfer was recognized by practically all the Great Powers, except Britain, who withheld her sanction till 1913. On May 29, 1913, Sir Edward Grey announced to the House of Commons the intention of the British Government to recognize the annexation of the Congo by Belgium and said that they were now fully satisfied that the condition of affairs had completely changed. While it shocks us that the atrocities should have gone on so long, it is probably true that at no previous stage in the world's history would the condition of uncivilized savages have been so much a matter of concern to the millions who had no personal interest in them.

Atrocities have been reported in the Putumayo district of Peru on the upper Amazon, some of the newspapers describing them as worse than those on the Congo. This is probably an exaggeration, but there have doubtless been very great cruelties inflicted upon the Indians there. But as the matter has been the subject of investigation not only by religious missions, but by a commission of the Peruvian government, as well as by a British government commissioner and by a select committee appointed by the House of Commons, it is to be hoped that the inhumanity is now at an end.

RECENT MATHEMATICAL ACTIVITIES

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MATHEMATICAL research generally thrives best in seclusion. The results are often embodied in a language which but few understand, and are then stored with a quietude secured and maintained by their own attributes. Now and then there are instances when unsolved mathematical questions get involved with enough external matter to attract general attention. This external matter often consists of an array of names of noted mathematicians who have been unsuccessful in their efforts to solve these questions.

When the solutions of such questions become possible, through special ingenuity or through the gradual development of the necessary elements, there is usually a stir in which mathematicians join the more heartily on account of its novelty. This fact may be illustrated by the famous memoir on the problem of three bodies by a Finnish mathematical astronomer named Karl F. Sundman, which the president of the Paris Academy of Sciences mentioned during the annual public session held on December 13, 1913.

This academy had previously appointed a committee to examine the work of Sundman, and the committee reported, through the noted French mathematician Émile Picard, that the memoir was epoch making for analysis and for mathematical astronomy. In accord with the recommendation of this committee, the Paris Academy awarded to Sundman the Pontécoulant prize, doubling its usual value. The report of the committee directed attention to the fact that Sundman achieved his results by means of classic mathematical methods.

In the April, 1914, number of *Popular Astronomy* Professor F. R. Moulton, of the University of Chicago, gave a very interesting popular account of the problem of three bodies and of the actual contribution made by Sundman towards its complete solution. From this account it is easy to see that a long list of eminent names are connected with this problem, including those of Newton, Euler, Lagrange and Poincaré, as well as that of one of the most illustrious American mathematical astronomers—the late G. W. Hill.

About two years ago a certain geometric question relating to the problem of three bodies came suddenly into prominence through an article by H. Poincaré, written shortly before his death, in which he called attention to the fact that he had not succeeded in finding a gen-

eral solution of this question. It is interesting to note that a young American mathematician, Professor G. D. Birkhoff, of Harvard University, had been thinking along similar lines and soon succeeded in finding a general solution. An article containing this solution was published in the *Transactions of the American Mathematical Society,* 1913, and a French translation of this article appeared recently in the *Bulletin of the French Mathematical Society.*

A number of important unsolved mathematical questions are constantly kept before the mathematical public by means of prizes offered by various foreign academies for definite contributions. The prominence of the Paris Academy of Sciences along this line is well known, and it would be difficult to determine the extent of the good influence exerted by these prizes. Moreover, special prizes are not infrequently instituted. The king of Sweden has recently authorized such a prize to be awarded, for important developments in the theory of analytic functions, during the meeting of the sixth international mathematical congress, which is to be held at Stockholm in 1916.

The monetary value of these prizes varies very much, but it generally does not exceed a thousand dollars. For instance, the prize offered by King Gustav V, of Sweden, to which we have just referred, consists of a gold medal and three thousand crowns (about eight hundred dollars) in money. The main value attached to these prizes is the recognition of the importance of the work of the authors honored in this manner, and this is especially valued by the younger investigators.

While prizes have greatly stimulated research activity in mathematics they have not furnished the main stimulus. The opportunities offered by the various journals to make useful development and interesting discoveries promptly known have doubtless furnished a stronger and more permanent stimulus, especially in those cases where the standing of the editors of the journals inspired great confidence. In America we have two journals which have rendered, and are now rendering, preeminent service along this line; viz., the *American Journal of Mathematics,* founded in 1878 with J. J. Sylvester as editor-in-chief, and the *Transactions of the American Mathematical Society,* founded in 1900 with E. H. Moore as editor-in-chief.

A current mathematical undertaking whose bigness would seem to entitle it to general interest is the publication of a large encyclopedia devoted to pure and applied mathematics. This work is being published, in parts, in the German and French languages. The first part of the German edition appeared in July, 1898. Since this time a large number of other parts have appeared at irregular intervals, aggregating at present about ten thousand large pages. Several additional parts are now in press, and it seems too early to predict when the entire work will be completed or how large it will become. The published parts would now

make twenty large volumes, each containing about five hundred pages.

While this work may appear extensive for an encyclopedia which aims to give in a *concise* form the fully established mathematical results, yet the French edition promises to become still more extensive. The first part of this edition appeared in August, 1904, and the aggregate of the published parts is at present only about one half as large as that of the German edition. On the other hand, most of the subjects which have been treated in both editions are treated with much more completeness in the French than in the German edition, as might be expected from the fact that the former edition is, in the main, based on the latter. According to the latest announcements some parts of the German edition are to be based on parts which have already appeared in the French edition.

The magnitude of these undertakings is certainly not the main element of interest to the educated man. In fact, the question has been raised whether these encyclopedias are not becoming too large to fulfil one of the main objects in view; viz., to provide a work by means of which the student can determine *quickly* what has been done along various lines in the mathematical sciences. A keen observer recently made the following significant remark, "the whole encyclopedia, whether German or French edition, seems of late to have run riotously and fruitlessly to leaves."[1] In this connection it may be observed that a big and vigorous tree has normally more leaves than a little one.

One of the main elements of interest in such big educational undertakings is the cooperation which it implies. This is especially true as regards a subject like mathematics, where the certainty and the permanence of conclusions tend to inspire unusual self-reliance and independence. The fact that the directors of these encyclopedias have secured the cooperation of nearly three hundred mathematicians of various nationalities implies that in this field also there is substantial evidence of organized effort on a large scale. It is of interest to observe that American mathematicians are fairly well represented among these collaborators.

A big current mathematical undertaking which affects directly a much larger number of people than the encyclopedias mentioned above is the work which is being done under the direction of the "International Commission on the Teaching of Mathematics." This commission was created during the sessions of the fourth International Congress of Mathematicians, which was held at Rome in April, 1908, and has for its main object a study of the methods and plans of mathematical instruction in different nations. At first it was intended that the commission should confine its work to secondary mathematics, but

[1] E. B. Wilson, *Bulletin of the American Mathematical Society*, Vol. 18 (1911–12), p. 465.

it soon appeared desirable to include all mathematical instruction in the scope of its investigation.

Sub-commissions were appointed in various countries. The American sub-commission is composed of D. E. Smith, Columbia University; W. F. Osgood, Harvard University, and J. W. A. Young, Chicago University. Under the general direction of these sub-commissions a vast amount of material relating to the mathematical instruction has been collected and published. In our own country this material was published by the U. S. Bureau of Education in the form of thirteen reports. Some of the other countries have not yet completed their work, but about one hundred and sixty such reports have already been published in the twenty-six countries which have joined in this vast undertaking.

In addition to securing these valuable reports the central commission has arranged international meetings for the discussion of some of the fundamental questions relating to mathematical instruction. Such a meeting was held in Paris, France, in April of the present year, and the two subjects under consideration were: (1) The results obtained by the introduction of differential calculus in the advanced classes of the secondary schools, and (2) the place and the rôle of mathematics in higher technical education.

Some of the leading French mathematicians (including Appell, Darboux, Borel and d'Ocogne) took an active part in the deliberations. Professor Borel emphasized the fact that mathematics is not composed of a linear sequence of theorems such that each depends upon the preceding one. If this were the case, the only possible changes in methods of instruction would relate to what theorems could be omitted in this sequence or what theorems could be substituted for others. On the contrary, the number of different routes leading from first principles to an advanced mathematical proposition is often exceedingly large, and hence arises the possibility of employing widely different methods to achieve the same general results.

In other words, mathematics is a network formed by intersecting thought roads and the chief aim of the International Commission on the Teaching of Mathematics is to secure extensive information as regards the choice of roads in various nations. The Italian member of the central committee, G. Castelnouovo of Rome, stated explicitly in his address during the recent conference at Paris, that the commission did not aim to bring about any great reforms, but aimed to gather facts as regards existing conditions in order that the various nations might be enabled to profit by the experiences of other nations in instituting their own reforms.

In describing mathematics as a network of a certain type of thought-roads, it is not implied that thought is conveyed along these roads as the products of a country are conveyed on a railroad train. On the con-

trary, thought is developed along these mathematical roads, and the traveler finds continually new difficulties whose solution depends largely upon those encountered earlier. In constructing these roads mathematics is not seeking an intellectual monopoly in order to collect toll from the rest of the intellectual world in succeeding ages. In fact, in most of the newer regions the travelers are too few to encourage such thoughts even if they were not intrinsically repugnant.

There is, however, a considerable number of mathematicians who are interested in constructing unusually attractive toll roads, especially in those regions where travelers are most abundant. Whether the prospects of tolls derived from small royalties constitute the best means to secure improvements in our elementary text-books and whether this system is apt to continue to be efficient are questions which present many difficulties. There appears to be an enormous waste along this line at present resulting from unfruitful duplication.

The financial questions involved in mathematical publications have doubtless much in common with those relating to the publication in other subjects. The journals depend largely upon the universities and the mathematical societies for financial assistance. Lately the *American Mathematical Monthly,* a journal of collegiate grade, has received financial assistance from more than a dozen colleges and universities, and it has thus been enabled to make many improvements. The *Annals of Mathematics,* which is a journal of a somewhat more advanced grade, is being published since 1911 under the auspices of Princeton University.

The large mathematical encyclopedias, mentioned above, are being published under the auspices of the Academies of Göttingen, Leipzig, Munich and Vienna, while various governments have been asked to assume the expense of the publication of at least some of the reports prepared under the general direction of the International Commission on the Teaching of Mathematics. The Japanese reports are published both in the Japanese and in the English languages; and all these reports, aggregating already more than ten thousand pages, are for sale by Georg & Co., Geneva, Switzerland.

While mathematical societies generally support publication of advanced grade, they usually have other functions. In many instances membership implies attainments of comparatively high order and hence is attractive in view of the honor and exclusive privileges which it involves. Recently an international mathematical society has been organized with the sole purpose of supporting the publication of the complete works of the most prolific mathematical writer, Leonhard Euler, who died in 1783. Each member of this society is expected to pay at least ten francs annually until this publication is completed, which is expected to require about fifteen years.

Several years ago it was estimated that the complete works of Euler

would fill from forty to forty-five volumes, and that the expense would be about half a million francs. As funds had been provided to cover this expense, the publication was begun, but it soon appeared that the estimates were entirely too low and that the expense would be almost twice as large as the original estimate, in view of the additional material found at various places.

The great permanent value of the works of Euler has encouraged the "Schweizerische Naturforschende Gesellschaft zu Lausanne" to make an appeal to all mathematicians, and others interested, to join hands by means of the society mentioned above in securing the completion of this monumental publication. This society seems to be unique in the history of mathematics, but it bespeaks forcibly the spirit of cooperation which has led in recent years to much bigger mathematical undertakings than were possible in former years. The reflex action of these big undertakings on the mathematicians themselves is an element of considerable interest.

The mathematical activities to which we have directed attention in the present article were selected, in the main, on account of their special interest at the present time. The most important activities, however, are those whose permanency has secured for them a place among the fundamental elements which enter unnoticed into our intellectual life, and whose effectiveness is increased by the fact that they are not impeded by effusion. As mathematics is such an old science, the educator naturally looks to its activities with a view to predicting in some measure the future activities of the younger sciences. Hence it is especially interesting to note those activities which imply vigor, and promise for still greater achievements in the mathematical sciences.

THE ULTRA-SCIENTIFIC SCHOOL

By B. HOROWITZ
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(THE ULTRA-SCIENTIFIC SCHOOL)
"Problems of Life are Problems of Matter."—Schäfer.

(THE CONSERVATIVE SCHOOL)
"To me the meanest flower that blows can give
Thoughts that do often lie too deep for tears."—Wordsworth.

THE addresses before the British Association for the Advancement of Science by Schäfer and Lodge have surely had the effect of stimulating still further our interest in the problem of problems—the origin of life. That the most profound differences of opinion exist not merely between scientists and non-scientists, but among scientific men themselves, adds but another factor to the general interest in the subject, though many factors to the general confusion.

The ultra-scientific school, at the head of which are Loeb and Schäfer, trace the origin of their ideas chiefly to Huxley. As far back as 1870 this philosopher wrote:

> With organic chemistry, molecular physics and physiology, yet in their infancy, and every day making prodigious strides, I think it would be the height of presumption for any man to say that the conditions under which matter assumes the properties we call "vital" may not, some day, be artificially brought together.[1]

That was before Emil Fischer began his work on the structure of the protein molecule; before Kossel commenced his celebrated investigations into the composition of nuclear material; long before Loeb startled the world with his experiments on parthenogenesis. With that intuitive spirit with which he was singularly gifted, Huxley foresaw—so claim our ultra-scientists—the results of modern research. Our chemistry, our physics, our physiology, have already reached that stage where we can say with confidence: the data necessary is within sight. Within these three sciences a complete explanation is to be found. Hence, outside factors need not be considered.

True, the mere fact that we can give no satisfactory definition of life can be of little avail in the present controversy. It may well be argued that we can do no better in the case of electricity, and yet our control of that is well-nigh complete.

It should be made clear, in justice to our ultra-scientists, that their aspirations at present run no higher than to bring the phenomena of life within the category of established laws. Their aim is to regulate

[1] Huxley, "Discourses" (Chapter on Biogenesis and Abiogenesis).

forces. To understand them is, they admit freely, beyond their ken. Thereby, even if their own problem were solved, a purely materialistic view would hardly be appreciably advanced.

But to return. Life, like electricity, can not be defined, but, like it, manifests itself in certain ways. Movement, metabolism, growth and reproduction are held to be characteristic properties of life by a large class of physiologists; but the insurgent group, with Wöhler's artificial production of urea—wherein he overthrew the idea that organic substances possess a "vital" force—as its foundation stone, is bent upon showing us that there is no such barrier between the animate and the inanimate. Is it movement that you are considering? Have we not that in organic mixtures, in oil drops, in globules of mercury? And are these not all explicable by changes in surface tension? Is it metabolism—the taking in of food and the giving out of waste products? If so, what of osmotic conditions, where solutions are separated by semi-permeable membranes and where there is an interchange of substance? Is it growth and reproduction? If so, consider the growth and multiplication of crystals.

It is this argument by analogy that has led the ultra-scientific school to its present theory with regard to the origin of life. Rightly brushing aside the meteoric theories of Kelvin, Helmholtz and Arrhenius as irrelevant in so far as origin goes—for in their attempt to explain the first sign of life on this planet they presuppose the existence of the germ elsewhere—Schäfer boldly upholds the hypothesis that life originated as a result of the gradual evolution of inanimate material. In process of time the simple substance became more and more complex and ultimately emerged as the living germ—the nitrogenous colloid.

But Schäfer goes a step further. Why are we to suppose that this happened but once, as all theories with regard to origin have thus far assumed? Why are we to suppose that at one time in the dim past a series of fortunate accidents made life possible? Is it not more logical to assume that these evolutionary processes are going on to-day and will continue to do so?[2]

Though even Huxley was of the opinion that at one time there was "an evolution of living protoplasm from not living matter," the idea that we should not relegate the process to some remote period in the past is a comparatively new one, and has not by any means received the approval of many otherwise loyal chemico-physiologists. These argue with no small show of reason, that continuous life production would imply similar terrestrial conditions throughout the ages; and this we know not to be the case.[3]

[2] E. A. Schäfer, "Life: Its Nature, Origin and Maintenance," Smithsonian Report, Publication 2213.

[3] Giving fancy full reign, Macallum pictures for us "a gigantic laboratory where there had been a play of tremendous forces, notably electricity, which

As growth and multiplication are by far the most characteristic features of the living organism, it is little wonder that the fiercest antagonism centers around this point. Mitchell, one of the mildest critics, takes exception to the crystal comparison, on the ground that living matter is a mixture of substances chiefly dissolved in water, and that therefore it would be far more appropriate to take liquids as the basis for comparison.[4]

Armstrong and Haldane, the one a chemist and the other a physiologist, and both among the most eminent in their respective professions, flatly refute the analogy. In crystal growth there is a mere piling up of simple units, and, under the proper conditions, there is no limit to the growth of the crystal. Nothing corresponding to cell division, nor to the complexity of organic growth, is ever met with. Bergson, whose knowledge of the exact sciences makes him an exceedingly competent critic, argues that whereas the living organism is composed of unlike parts and performs diverse functions, the crystal neither consists of the one nor performs the other.[5]

Of course, Bergson repudiates Schäfer's whole hypothesis, but in this he is in agreement with many a scientific authority. For example, Professor Wilson, whose book on cell development is a classic, sums up his views in these words:

> The study of the cell has, on the whole, seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world.[6]

Sir William Tilden, the English chemist, is equally emphatic from the chemical standpoint. He writes:

> Far be it from any man of science to affirm that any given set of phenomena is not a fit subject of inquiry, and that there is any limit to what may be revealed in answer to systematic and well-directed investigation. In the present instance, however, it appears to me that this [the origin of living matter] is not a field for the chemist, nor one in which chemistry is likely to afford any assistance whatsoever.[7]

Let it at once be stated clearly and emphatically that the ultra-scientific view is based primarily upon analogy—a very valuable method provided it is not carried to excess, and provided, also, sufficient experimental data are at hand. Mendeleëff's periodic classification tended to show that cæsium, rubidium, sodium and potassium were closely allied,

might have produced millions of times organisms that survived but a few hours, but in which, also, by a favorable conjunction of those forces, what we now call life might have come into existence.'' No less fanciful is Armstrong himself (see H. E. Armstrong, ''The Origin of Life: A Chemists' Fantasy,'' Smithsonian Report, Publication 2214). And yet we speak of the dry-as-dust scientist!

[4] P. C. Mitchell, ''Encyclop. Brit.,'' 11th ed., article on ''Life.''

[5] Bergson, ''Creative Evolution,'' p. 12.

[6] E. B. Wilson, ''The Cell in Development and Inheritance,'' p. 330 (1907).

[7] Tilden, *London Times*, September 10, 1912.

a fact which was known before Mendeleëff's time purely as a result of experimental work on these elements. The movement of oil drops and the interchange of substance in osmosis are certainly quicksand foundations upon which to build inter-relationship theories of the animate and the inanimate. This superficial connection fails to stand the test of adaptation and coordination—to name two characteristic features of the *vital* substance. Indeed, our knowledge is so remarkably extensive that we can not as yet state the simplest *vital* manifestation in terms of science.

But this does not make a discussion of this kind any the less valuable. The impetus to research that it gives is productive of the highest good to mankind, for if the results do not solve the problem, the *scope* of the problem becomes so much clearer. The whole, which is made up of many coordinated components, eludes the grasp, but the individual components are gradually revealing many of their secrets to the untiring scientific explorer. With the physiologist ever attentive in his study of the human mechanism, with the chemist carefully analyzing and synthesising the more complex forms of matter so intimately associated with life's activity, with the scientific philosopher investigating the laws common both to animate and inanimate substance, who would venture to foretell the outcome?

The present situation may be summed up in some such way as this:

1. (*a*) Chemistry and physics may possibly contain all the necessary factors, our ignorance being due to our inadequate knowledge of these sciences, especially chemistry; or (*b*) There may be an outside factor.

2. Whilst no definite theories as to the origin of life can as yet be advanced, it is not unreasonable to suppose that in process of time, with consequent development, a better insight into (*a*), or an idea of (*b*) will be obtained. Fancy may well picture even the acquirement of new faculties, which will bring within range many of nature's present secrets, unattainable by present methods.

3. At present we know of no better way of pursuing our search than through the sciences. But here we are only safe when we apply them to the things we can grasp. The application of scientific methods to the spirit world (the methods of Crookes, Lodge and others) have thus far been barren of result. Science, *as we understand it,* rules in the world of matter, but it does not beyond. Whether this "matter" is but a manifestation of the "spirit," whether there is any relationship between them, or whether, indeed, they spring from the same source, time may, and time may not tell. Our duty is to plod the weary way, irrespective of where it leads to, or what the outcome of it may be. Patience, diligence and truth are our guiding stars.

ARABIAN AND MEDIEVAL SURGERY[1]

By Dr. JOHN FOOTE
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AFTER the conquest of Alexandria, when the victorious Mohammedans were feeding the fires of the city baths with the priceless treasures of the Alexandrian library, a young man who had been a student at the now dismantled university was writing a medical work, the sixth volume of which dealt with surgery. Little work has been done by the Byzantine authors other than the copying of preceding works which might otherwise be lost to us, and the works of Oribasius and Ætius on surgery and the medical writings of Alexander of Tralles have little more than their Greek contact to commend them. But the work of Paul, called from his birthplace, Paul of Ægina, was more than a mere copy. The rough, untutored Arabs who conquered Asia Minor, were not long in being, in turn, conquered by Greek culture and Greek science. Rapidly as this was assimilated, it is well to remember that an important text-book on surgery had been written by one of the conquered before the Hellenization of the Arab had taken place. Gurlt considers this a momentous work, and it describes among other things original treatment for foreign bodies in the esophagus, the operation for tracheotomy, and has an article on hernia. Of course this surgeon had an operation for the radical cure, which included peritoneal suture and drainage in its technique. Paul devised a gynecological speculum, was credited with special knowledge of women's diseases, and indeed was known as "The obstetritician."

The Nestorian monks had christianized many Arabs and these Christian Arabs figure most prominently in the first period of Arabian medicine as both translators and practitioners. The Bachtischua family, the name being derived from Bocht Jesu, servant of Jesus, had several illustrious members, the first, George, being physician to the caliph El Mansur at Bagdad, and his son, as well as his grandson Gabriel, serving Haroun al Raschid in a like capacity. This physician claimed to have received over $10,000,000 in fees, and the largest single fee on record, $125,000, is credited to him. Perhaps the best known writers of this period were Serapion, the Elder, who lived during the ninth century, and Honein Ben Ischak, or Johannitius, whose accurate translations of the old authors caused him to be called the Erasmus of the Arabian renaissance. Serapion describes an operation for stone in the kidney in which

[1] Read before the Medical History Club of Washington, D. C., December 27, 1913.

an incision is made in the groin and the pelvis incised and explored. He did a ligation operation for hemorrhoids, wrote in detail on the use of the catheter, and considered the suprapubic opening of the bladder for stone a simple procedure if we can believe him.

The Jewish physicians are important figures in this period of the history of medicine. Many of their scholars attained distinction as surgeons and writers; the best known of these, Maimonides, or Moses Ægyptius, was surgeon to Saladin and lived in the twelfth century. Spain, the rich Roman province which had produced Lucan, the Senecas, Martial and Quintillian, did not entirely lose its traditions of culture after the barbarians from the north fell upon it, and the Moors, hungry for knowledge, came to a feast of which they were soon the masters.

The most distinguished Arabian surgical writer of the ninth century was Rhazes, a Persian by birth, who was a singer until he was thirty. He was a follower of Aristotle and Galen and wrote some 200 works, including a complete system of medicine and surgery. He treated fractures with intelligence and discussed the treatment of wounds of the intestine. Vesalius thought so well of his principal work that he translated it, but later destroyed the translation. Ali Abbas, who succeeded Rhazes in prestige, wrote a book, the Liber Regis, dedicated to his patron the Sultan. This was the leading Arabian textbook until the Canons of Avicenna appeared. A method of ligating the median basilic vein in troublesome hemorrhage after venessection is described, as well as the technique of tapping the peritoneal cavity in ascites. This work was translated by Constantine, and printed in Venice in 1492.

Albucasis, a Spanish Moor, born, like Maimonides, near Cordova, was probably the greatest of the Arabian surgeons. He lived in the second half of the tenth century, and is reputed to have attained the age of 101. While his writings cover the entire field of medical knowledge, his three volumes on surgery are most original, and are the first illustrated surgical writings that have come down to us. Fabricius, Harvey's teacher, declared that he owed most of his knowledge to three writers, Celsus, Paul of Ægina and Albucasis. Albucasis emphasized the importance to the surgeon of a knowledge of anatomy. In discussing the treatment of hemorrhage he advises the use of the cautery, complete division of the partially severed artery, hemostatic applications and bandaging. He classifies nasal polyps, advises the snare for their removal, has ingenious methods for removing foreign bodies from the ear, makes some advances in genito-urinary surgery, and differentiates between epitheliomata and condylomata. He talks of the extirpation of varicose veins, but wisely says this operation should not be resorted to unless absolutely necessary. He diagnoses fracture of the pubic arch, and when it occurs in the fe-

male he advises a vaginal tampon of wool, or of a blown up sheep's bladder. Avicenna, the author of the "Canons," was a medical rather than a surgical writer, and his text-book was used for nearly five centuries after it was written.

Bagdad and Cordova had now become the destination of many a European scholar. The number of anatomical terms of Arabian origin translated into Latin, according to Hyrtl, is surprising, and this more especially in view of his assertion that "the Arabs paid very little attention to anatomy, and, of course, because of the prohibition of the Koran, added nothing to it." He continues:

> Whatever they knew they took from the Greeks and from Galen. . . . They delighted in theory rather than practise.

This is a terse summing up of the general influence of Arabian medicine. Taken as a whole, the Arabs were copyists and dialecticians; by their very virtues of erudition and scholarship they impressed upon their medieval successors the supremity of Galenical tradition rather than the desire for anatomical and bedside inquiry into the cause of disease.

Constantine Africanus, who was first a traveler and a student, next a professor in the University of Salerno, and finally a Benedictine monk in the great abbey of Monte Cassino, is the connecting link between Arabian and western medicine. His familiarity with oriental languages, and his connection later with the great Benedictine order celebrated for its libraries and zeal in copying books, gave him unique opportunities for the translation and circulation of his medical writings. He was born at Carthage early in the eleventh century, and died near its close. After his travels he acted as physician and secretary to Duke Robert of Salerno, and was made professor of medicine at the university. After teaching for ten years he retired to the monastery, obtaining there both the quiet and the material assistance which he needed in order to pass his heritage of knowledge on to succeeding generations. The "Liber Pantegni," a translation of Ali-Ben-el Abbas, as well as certain works of Hippocrates and Galen, were among his best-known books. His original work is better known through the writings of his students Afflacius, Bartholemew and numerous others.

In view of this it is a seeming contradiction to have Gurlt assert that the surgery of the Salernitian school was not a continuation of Arabian surgery and that the surgeons of Salerno were not influenced by the Arabian commentators. Yet he cites Roger's writings in evidence, and declares that such authorities as are quoted come directly from the Greek, while a good portion of the work rests on the writer's own experiences.

Contrary to popular belief, surgery at this time was not an unlearned profession, for there were many surgeons connected with the early uni-

versities. The degradation of the surgeon comes later in the middle ages. The greatest surgical teacher of the early thirteenth century was Roger, who wrote about 1180. His work was annotated by his pupil Roland, and the work of both edited later by the Four Masters. Gurlt says of the latter:

This volume constitutes one of the most important sources for the history of surgery in the later Middle Ages, and makes it very clear that these writers drew their opinions from a very rich experience.

Their diagnosis of fractures of the skull is quite modern, subdural hemorrhage is described, and the technique is given for a decompression operation for depressed fractures, the old writers saying:

In elevating the cranium, be solicitous lest you infect the dura mater.

Suturing with silk, and drainage, are recommended for scalp wounds, and the prognosis of infected wounds is considered at length. The surgeon was told that he must keep his hands clean and that he must especially avoid not only menstruating women, but all women, if he would operate successfully.

Bruno da Longoburgo, Theodoric, Hugo of Lucca, and William of Salicet are a famous group of North Italian surgeons of this period. Mondino, the author of the first book on dissection, Lanfranc, who taught at Paris, and, in the words of Pagel, "gave that primacy to French surgery which it maintained all the centuries down to the nineteenth," as well as de Mondeville and Guy de Chauliac, belong to the early fourteenth century.

Hugo of Lucca and his son Theodoric used opium and mandragora to produce anesthesia, and also used a mixture to be inhaled from a sponge, the composition of which is not definitely known. Fifteen great universities arose in Italy from the tenth to the fourteenth centuries, and in all of these surgery was taught. Bruno was the first of the Italian surgeons to quote Arabian as well as Greek authorities. He worked at the universities of Vicenza, Padua and Verona. His "Chirurgia Magna" was completed at Padua in 1252. He insisted that surgery was largely handwork, and must therefore be learned from practical experience and observation. He sums up three important offices of surgery as: "to bring together separated parts, to separate those abnormally united and to extirpate what is superfluous." He discusses wounds, healing by first and second intention, indications for suturing and for drainage. He advised against the use of water in wounds, especially the water in camps and battlefields. Wounds of the intestine he directed to be cleansed with warm wine and closed with fine silk sutures.

Hugh of Lucca was city physician to Bologna, and his writings were edited by his son Theodoric. Theodoric studied medicine, entered the Dominican order at the age of 23, but continued to practise surgery in Bologna, devoting his fees to charity. At 50 he was made a bishop. In his text-book, finished about 1226, he says:

All wounds should be treated only with wine and bandaging.

He emphasized the importance of diet in assisting in wound repair, warned against the wounding of nerves, and suggests bringing ends of cut nerves in proximity to favor repair. It is surprising to find these old surgeons writing of union by first intention, and insisting on cleanliness and antiseptic dressings, such as strong wine. With regard to their treatment of wounds, Professor Allbutt, of Oxford, undoubtedly our greatest English authority on the history of medicine, writes as follows:

They washed the wounds with wine, scrupulously removing every foreign particle; then they brought the edges together, not allowing wine nor anything else to remain within—dry adhesive surfaces were their desire. Nature, they said, produces the means of union in a viscous exudation, or natural balm, as it was afterwards called by Pare and Wurtz. In older wounds they did their best to secure union by cleansing, desiccation and refreshing of the edges. Upon the outer surface they laid lint steeped in wine. Powders they regarded as too desiccating, for powder shuts in decomposing matters; wine, after washing, purifying and drying the raw surface, evaporates.

Theodoric was six centuries in advance of his time when he wrote:

For it is not necessary, as Roger and Roland have written, and as many of their disciples teach, and as *all modern surgeons profess*, that pus should be generated in wounds. No error can be greater than this. Such a practise is indeed to hinder nature, to prolong the disease, and to prevent the conglutination and consolidation of the wound.

Theodoric, like our present-day surgeons, was proud of his small and beautiful scars produced without using salves "Pulcherrias cicatrices sine unguento aliquo inducebat," while poultices, oils and powders on wounds, he said, incarcerated foul material, "saniem incarcerare," evidence enough that this writer knew not only the art, but also the fundamental principles of good surgery.

William of Salicet passed his early life at Bologna, and later was municipal and hospital physician to Verona. Being himself both a physician and a surgeon, he believed that these two branches of medicine should not be separated. In his book he quotes previous authorities less than his predecessors, and he condemns the abuse of the cautery popularized by Arabian writings, and advocates the use of the knife. He describes operations for the relief of hydrocephalus, various eye conditions, nasal polypi and tumors of the mouth. He relates the history of a tumor, probably an epulis, larger than a hen's egg, which he removed from the gums of the upper jaw, and says that he performed the operation in four steps, the last being the resection of a portion of the jaw bone. He did not hesitate to operate on cystic goiter, but he describes the large veins encountered in certain types of goiter and he warns against hemorrhage from them.

Lanfranc practised at Milan until his banishment about 1290. He

then practised at Lyons, and later taught at Paris, where he attracted great numbers of students by his fame as a teacher and an operator. He completed his "Chirurgia Magna" in 1296. Ten years later he died, but meanwhile he had transferred the center of the surgical world from Italy to France. Lanfranc was probably the first surgeon to absolutely distinguish between nerve and tendon, and he was the first to advocate and practise nerve suture.

Henry de Mondeville, or Henricus, was a Norman, little known until modern times. The first printed edition of his book was edited by Professor Pagel, in Berlin, in 1892. Mondeville was a scholar and a traveler. Born in France, he studied under Theodoric in Italy, and later at Montpellier and Paris. He afterwards lectured in both of these universities. He was a very busy man—a teacher, a consultant and one of the physicians to King Philip le Bel. We see in him the not unfamiliar picture of the famous surgeon trying to make time for his writing. He died before he was forty of some lung disease—probably tuberculosis. He sketched the earlier chapters of his work on his sick bed, but wrote the practical portion at length in the last chapter so that his students might profit by his experience. He was a shining example of the wide culture and erudition of the university-trained surgeon of his day, quoting, as he did, not only from the Latin, Greek and Arabian authorities on medicine, but also from Cato, Diogenes, Horace, Ovid, Plato, Seneca and other classics not popularly known until the Renaissance. Mondeville used a large magnet to extract portions of iron from tissues, and invented an instrument for extracting barbed arrows from the flesh. He wrote intelligently on the nursing problem, and spoke of the difficulties to the surgeon when wives nursed their husbands. A chapter on the history of surgery is a novel feature of his book. He was one of the first, if not the very first, to use illustrations in teaching anatomy.

Yperman, who was sent by the town of his name in Belgium to Paris in order to learn surgery, fulfilled his mission, and returning to his native town, practised and wrote two books on surgery in Flemish. John Ardern, an Englishman, studied at Montpellier, and, returning to England, practised and wrote on surgery. The "Practica" is a comprehensive work by this English surgeon, containing many case histories. He was a skillful operator, especially famed as a proctologist, and was the first surgeon to collect careful statistics of his cases. His book is illustrated, and he writes on what we now recognize as appendicitis under the title "Against Colic and the Iliac Passion." Ardern was the first great English surgeon.

We are inclined to deny to the middle ages anything approaching our tolerance of thought in the domain of education. The idea of coeducation, and women in the learned professions, would seem to be

essentially modern. Coeducation was tried in the middle ages and found wanting, and women taught in the medieval universities, and were eminent as physicians, gynecologists and obstetricians. Salerno admitted women to the study of medicine, and women's diseases were taught entirely by women teachers. The most famous of these was Trotula, said to have been the wife of one of the professors. She wrote two books, the most important one being called "Trotula's Wonderful Book of Experience in the Diseases of Women, Before, During and After Labor, with All Other Details Likewise Relating to Labor." Prenatal care, nursing and the care of mother and child during the puerperium are considered. In the chapter on the perineum a description is given of a complete tear, together with directions for a radical cure in which sutures with silk thread are employed. This author writes:

> The woman is then placed in bed with the feet elevated, and must remain in that position even for eating and drinking and all the necessaries of life, for eight or nine days. During this period, also, there should be even no bathing, and care must be taken to avoid everything that might cause coughing, and all indigestible material.

All students of obstetrics might read with profit her directions for care of the perineum during labor. She says:

> In order to avoid the aforesaid danger, care should be taken . . . somewhat as follows: a cloth should be folded somewhat in oblong shape and placed on the anus, so that, during every effort for the expulsion of the child, that should be pressed firmly in order that there may not be any solution of the continuity of tissue.

Her works were printed at Strassburg in 1544, and in Leipsig as late as 1778. Nicaise, Chauliac's biographer, says:

> Women continued to practise medicine in Italy for centuries, and the names of some who attained great renown have been preserved to us. Their works are still quoted from in the fifteenth century. . . .

Chauliac criticized women surgeons of his day for being too timid in taking chances, and refusing to operate on dangerous cases. There were at least seven women professors at Salerno who wrote works that have survived. One of these, Mercuriade, was a surgeon, and wrote "On the Cure of Wounds." Another one, Abella, wrote "On the Nature of Seminal Fluid" and "Black Bile." Rebecca Guarna wrote on "Fevers," "The Urine" and "The Embryo."

The last great name in medieval surgery is Guy de Chauliac, that brilliant man who, both chronologically and in virtue of his methods, may be looked upon as the father of modern surgery, if indeed that distinction may be conferred upon any one individual. Born in southern France late in the thirteenth century, he was educated at Montpellier, and then journeyed down to Bologna in Italy, to do post-graduate work in surgery, finally finishing his studies in Paris. One of his teachers

at Montpellier was Bernard Gordon, author of "Lillium Medicinæ," and a fellow student was John of Gaddesden, the first English Royal Physician, who is mentioned by Chaucer in his "Doctor of Physic." Guy did not like John's Book, "Rosæ Angliæ" because it lacked originality and clung to authority unsupported by experience. At Bologna he studied under Bertruccius, and he relates how "very often" to quote his exact words, his master dissected dead bodies in four lessons. His attitude toward anatomical study is shown by his expression, "The surgeon ignorant of anatomy carves the human body as a blind man carves wood." He practised first in his native province, later in Lyons, and finally was physician and chamberlain to three successive popes at Avignon. He occupied the latter part of his life with writing his "Chirurgia Magna," his "Solatium senectutis," he called it. Nicaise emphasizes the freshness and originality of Guy's viewpoint, and quotes him concerning the surgeons of his own and preceding generations as follows:

> One thing is especially a source of annoyance to me, in what these surgeons have written, and it is that they follow one another like so many cranes. For one always says what the other says. I do not know whether it is from fear or from love that they do not deign to listen except to such things as they have been accustomed to, and as have been proven by authorities. They have to my mind understood very badly Aristotle's second book of metaphysics when he shows that these two things, fear and love, are the greatest obstacles on the road to the knowledge of the truth. Let them give up such friendships and such fears.

For while Socrates or Plato may be a friend, truth is a greater friend.

> . . . Let them follow the doctrine of Galen which is entirely made up of experience and reason, and in which one investigates things and despises words.

In writing on surgery of the brain he records the loss of brain substance with recovery, and notes the recovery, under expectant treatment, of many patients with suspected fracture of the skull. His study of the surgical anatomy of the ribs and diaphragm as applied in opening the thorax, shows sound surgical sense. In wounds of the intestines he gives an unfavorable prognosis unless the abdomen be quickly opened and the wounds sewed up. He describes his sutures and his special needle-holder, like any modern surgeon. In his chapter on amputations he writes on the use of opium, morel, hyoscyamus, mandragora, ivy, hemlock and lettuce to abolish pain during operations, and also refers to inhalation anesthesia, from a sponge soaked in various sleep-producing drugs. Taxis and reduction in hernia were developed by him, and he invented several trusses. Many operations for hernia, he wrote, benefited the surgeon more than the patient. In strangulation he insisted upon immediate operation. He describes six hernia operations, and criticizes all of them, easily enough, since all of the operations at this

time included removal of the testicle. He alludes to the use of gold wire, a forerunner of the silver wire of our day. His inventions for the reduction of fractures and dislocations were far in advance of his day and many of these cases were cared for in hospitals. Virchow has told us of the excellence of the hospitals in the thirteenth century, and of the good care given to the patients. How Chauliac and later generations of surgeons came to accept the doctrine of the formation of laudable pus in wound healing, when at this period surgical cleanliness, the use of antiseptic wine dressings, and the possibility of natural union by viscous exudate were written on and discussed, is difficult to understand. But even in Chauliac's time, surgery was becoming more and more divorced from medicine, and the surgeons were ceasing to be students.

Chauliac was a genius living in an age of remarkable achievement. Dante's "Divine Comedy" and Petrarch's sonnets were written in his lifetime. Boccaccio and Chaucer were of his day. Giotto was painting wonderful pictures, the great cathedrals were building and the universities were flourishing, and as Professor Huxley said in his rectorial address at Aberdeen, in 1847, "probably *educating* in the real sense of the word better than we do now." Portal in his "History of Anatomy and Surgery" says:

> Finally, it may be averred that Guy de Chauliac said nearly everything which modern surgeons say, and that his work is of infinite price, but unfortunately too little read, too little pondered.

This obviously extravagant praise is not discounted by Albutt who writes:

> This great work [the "Chirurgia Magna"] I have studied carefully and not without prejudice: yet I can not wonder that Fallopius compared the author to Hippocrates or that John Friend called him the Prince of Surgeons. It is rich, aphoristic, orderly and precise.

Decadence in surgery began after Chauliac's death. His successors seemed to think that they had little more to learn, and boasted, as each generation does, of their progress. Wars and political disturbances also came to distract men's minds, and study and achievement ebbed away from the standard set by Guy and his immediate predecessors, until the great flood tide of knowledge that came with the Renaissance.

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CIVILIZATION AS A SELECTIVE AGENCY

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WRITERS of recent years appear to agree that there has been little or no improvement of civilized man through selection. Since the dawn of history, it is recognized that many selective forces, some favorable, some deleterious, have acted on the human breed; but it is denied that any constant and effective agency which would bring about a marked advance in moral and intellectual quality has been in operation. August Weismann expressed himself on this score clearly, though with scientific reserve. He said:[1]

> But as a mere suggestion, without any pretense to exactness, I will state that the people of "antiquity," viz., the ancient civilized nations of the Mediterranean, had already, at the very dawn of their history, attained the highest level of intellectual development. If any further growth has occurred since in European states, it certainly has been so imperceptibly small that it could cause no sensible difference in the susceptibility of the human soul to music. The times which produced such legislators as Moses and Solon, poets like Homer and Sophocles, philosophers and men of science like Aristotle, Plato and Archimedes—times which created the Egyptian temples and pyramids and the statues of the Greek gods, most undoubtedly display the achievements of the human intellect at its best. And an age which produced the gentle and forgiving Christian philosophy shows us that, as regards character and feeling, the human mind had attained the highest development.

This view has come, indeed, to be orthodox. Except among thinkers who still cling to the Lamarckian doctrine, it is generally accepted. It is taken over without reservation in many books on social theory.[2] According to this principle our inheritance is primitive inheritance. The growth of the social heritage, rather than changes in the racial heritage, has wrought civilization for us and bridged the gap between aboriginal Teuton and modern German. Mankind may have progressed, certainly has altered, but for cause we must look to "those contrivances which enable human beings to advance independently of heredity."[3]

Among writers of authority possibly no one has given more emphasis to this conception that Alfred Russel Wallace, codiscoverer with Darwin of natural selection. In his latest book[4] Wallace reiterates the conclusion:

1 "Thoughts Upon the Musical Sense in Animals and Man."

2 For example, see Simon N. Patten, "The New Basis of Civilization," p. 169.

3 D. G. Ritchie, "Darwinism and Politics," p. 101.

4 "Social Environment and Moral Progress," p. 102.

that the higher intellectual and moral nature of man has been approximately stationary during the whole period of human history, and that the cause of the phenomenon has been the absence of any selective agency adequate to increase it.

Somewhat earlier than this Wallace asked:[5]

> Looking back at the course of our history from the Saxon invasion to the end of the nineteenth century, what single cause can we allege for an advance in intellect and moral nature? What selective agency of "survival value" has ever been at work to preserve the wise and good and to eliminate the bad? And it must have been a very powerful agency, acting in a very systematic manner, even to neutralize the effect of the powerful deteriorating agencies above referred to.

And again:

> there is no good evidence of any considerable improvement in man's average intellectual and moral status during the whole period of human history.

At one point in this essay, as a matter of fact, Wallace goes so far as to say, after discussing the ways in which the human breed was brutalized by the withdrawal of the more refined natures to monasteries and nunneries, and the destruction of radicals and students during the witchcraft mania and by the inquisition, that:

> we are to-day, in all probability, mentally and morally inferior to our semi-barbaric ancestors.

Must we accept this view as final? Are we sure that a denial of selection during historic times, strongly supported as it is, expresses the whole truth? In the first place, it certainly runs counter to the wide-spread belief that men are to-day inherently more humane, kindlier in character and action, than they were in antiquity. Attention is often called to the growth of altruism, especially during the past century. It is maintained that suffering will not be endured, either among men or animals, as in former times; that cruel punishments have been abolished; that brutal sports, once popular, now only disgust and repel. Further evidence of increasing altruism is offered in the development of social legislation, and in the multiplication of charitable and educational enterprises. And it must be admitted that the twentieth century, with its vast philanthropies, its soft-heartedness, verging so often even to sentimentality, and its insistence on the ideal of service, belongs to a different world from the hard life of the Greek and Latin city states, which seem, sometimes, in their unthinkable indifference to human pain and the rights of the weaker, to be prototypes of nothing modern except the Camorra and the Mafia.

This notion that the human breed is now, in civilized societies, kinder, gentler, more tractable, is not merely a popular idea. One phase of it has been remarked upon by that keen observer, Walter Bagehot.[6]

[5] "Evolution and Character," *Fortnightly Review,* Vol. 89, 1908, pp. 1–24.
[6] "Physics and Politics," p. 25.

> They both (Aristotle and Plato)—unlike as they are—hold with Zenophon—so unlike both—that man is the "hardest of all animals to govern." . . . We reckon, as the basis of our culture, upon an amount of order, of tacit obedience, of prescriptive governability, which those philosophers hoped to get as a principal result of their culture.

Bagehot, of course, had no difficulty in explaining this increase in social amenability which he believed he observed. He had accepted the idea that acquired characters are inherited; and he thought that our modern orderliness and sympathy would be attained "when the soft minds and strong passions of youthful nations are fixed and guided by hard transmitted instincts." But if we rule out this agency, and adhere to the position of Weismann, now generally acknowledged as correct, we must forego this easy explanation and seek some other reason than the transmission of acquired characters for the world's increasing moral stability.

There remain two possible views to be taken of the fact that the moral complexions of the ancient world and the modern are so different. First, we may accept the orthodox dictum, and maintain that any apparent changes are due to the increased weight, so to speak, of the race's moral heritage—to strengthened social controls and the ascendency of new ethical types; or secondly, we may postulate a change in man's innate moral nature, accompanying and reenforcing the influence of the augmented social heritage. We shall be justified in pursuing the second, and bolder, course only if we can discern some selective agency adequate to effect the change.

It is here suggested that such a selective agency can be discerned as operative, an agency at once powerful, comprehensive and continuous. We may denominate it the *elimination of the anti-social*—that is, the constant cutting off of those elements in society which do not fit in with the requirements of orderly civilized life. The forms that this process has taken—a number of which we shall examine shortly—have been many and diverse; but the result has been unified and focused.

Settled community life creates an environment of its own, imposing new requirements of "fitness." A heavy survival value comes to attach to tractability, so that non-conformity, in greater or less degree, leads to extinction or failure to beget offspring. The church and the state cut off the anti-social person by capital punishment, imprisonment and banishment; while the anti-social individual eliminates himself by suicide, by choice of a dangerous occupation, by withdrawal to the world's frontiers, by exposing himself to vice and racial poisons. Those who tend to survive and perpetuate themselves, on the other hand, are those whose moral natures make the restraints of sedentary communal life less irksome.

It would not be possible—nor is it necessary to our present purpose

—to draw a sharp line between the social and the anti-social. That psychology of individual differences which might enable us to grade men and women into distinct ethical types is still in process of creation. Yet in a broad empirical way it is easy to distinguish the moral qualities favorable to communal life. The complete social person is marked, fundamentally, by industry, self-control, kindliness, perseverance and the ability to subordinate present pleasure to future welfare. Anti-social persons embody the opposite characteristics—shiftlessness, violence, brutality, predatory tendencies, viciousness and impatience at restraint. Of course these qualities, social and anti-social, combine in all sorts of mixtures in all sorts of persons. But the principle is clear. As nature's standards of fitness become progressively more civil the social qualities stand a better and better chance, in contrast with their opposites, of perpetuation.

One reason thinkers have overlooked the existence and operation of this selective factor has been a too great preoccupation with the question of intellectual and moral *improvement*. This, as we shall note later, has led to wrong inferences from the data. The problem, in fact, is not one of advance, but one of change. Another source of error has been a confinement of attention to group selection, leading to excessive emphasis of the importance of military success, and neglect of internal selective processes in semi-military communities.

It has long been recognized, of course, that before the emergence of civilizations along the Nile and the Euphrates the race had been subjected to discipline for hundreds of thousands of years. Men lived in groups where tribal custom was supreme. The necessity of prolonged care during infancy had sifted out the gentler mothers and fathers. The clans, moreover, waged incessant war among themselves; and fighting strength and pugnacity being equal, the clan most solidly cemented by fellow feeling succeeded in the conflict with less adhesive clans. Social solidarity, crystallized and preserved in the "cake of custom," stood at a survival premium. Therefore at the beginning of civilization selection had already picked out and conserved a certain minimum of tractability.

Was this rôle of selection dropped with the passing of the predatory pastoral stage and the setting up of orderly communal life? Has the capital of cooperative spirit, acquired before the pyramids, sufficed for all subsequent elaborations? Is not the truth rather that, although the mode of eliminating the anti-social elements has altered, the process has been continuous? Men began to be graded into classes, into occupations and castes. Up to that time man's nature had been clan-hewn. Thereafter selection worked on the individuals within the group, sifting them out in their extensive variety.

II

We may now examine a number of the ways in which this form of socialized selection has worked. Here we shall not try to proceed chronologically, or attempt to strike a quantitative balance between this and other selective forces operating within historic times. Yet by a sketchy enumeration of the factors we may, possibly, suggest how stringent and unrelenting has been the elimination of the anti-social.

In the first place, obviously, the state itself is constantly trying to grind out of society its elements of friction. To-day murderers are executed, and lesser criminals separated from their families and imprisoned; but the penal regulations of the present are charity itself compared with the harsh punishments of the past. For centuries a gallows decorated every cross-roads in Europe, and malefactors, great and petty, were ruthlessly weeded out. Even a hundred years ago in England there were two hundred and twenty-three crimes punishable by death. Throughout the stressful past persons who preferred theft to industry, who scorned constituted authority, who were heedless of the rights and pains of others, were—when caught—swiftly annihilated. Mutilations, shortening life, were so common that the highways were frequently crowded with maimed beggars. Despite the chaos of medieval times life was hazardous for the predatory—at least for the predatory poor.

Again: for many centuries rebellions have been suppressed with bloody finality. Although quickness to rebel, boldness to defy, do not necessarily mark a man as anti-social, yet meekness and a bending to authority, like forbearance, are bound up temperamentally with a kindly disposition and brotherly love. It must be further remembered that the persecutions of the church in all ages have cut off the recalcitrant along with the liberal. Although there has been loss in originality, there has been gain in pliancy. Some of the martyrs were more anarchists than saints. Finally, under the head of legally enforced conformity stands the fact that practically all the civilized race has passed, at one time or another, under a régime of slavery or serfdom. Captives have often come to form, after a few generations, the bulk of the population of the conquering nation. The slave is seldom free to propagate, or, frequently, to live, against the will of his master; so that the descendants of slaves and serfs are bred from the most docile and most industrious of the first generations. Slavery as an institution has vanished, but its effects on human reproduction have been far reaching; for thus man aided directly in his own domestication.

We next consider those various modes of elimination which may be grouped under the term voluntary withdrawal. Suicide during early life effectually abolishes an anti-social strain. The person who has lost

the will to live is one who, speaking in the large, has found the conditions of civilized existence unbearable. Suicide as a selective agency is not negligible. The present annual rate for European countries runs above one hundred per million of living; and every day in the year there is a self-murder in the Prussian schools.

Occupational and geographical withdrawal, furthermore, is more significant than withdrawal from life. The hardy, callous, near-savage type of man has ever been employed to do the rough and dangerous work of civilization. From this obdurate material has, in all stages of industrial development, been drawn the sailors, the miners, the range-riders, the pioneers. The bonds of civilized life moreover, are an irritation to many strong and reckless spirits. Such cut loose; for so long as people live together in a net of social interrelations, some overactive elements will break through to the freer life of adventure. Hazardous occupations and adventurous callings have offered opportunity for segregation and voluntary exile. Who, from the first, have been our explorers, our soldiers of fortune, our gold-seekers? Of what stuff are the lads who, in all times, have "run away to sea" or "gone West"? Surely not those who were succeeding best in their trades, not the young men of peaceful ambitions, not those enamored of family life. In somewhat the same class are those restless or slothful souls who take to "the open road." The number of professional tramps in this country is about two hundred thousand. Their occupation is to avoid work: they are anti-social.

It is plain that those who withdraw socially or geographically from their kind contribute less than their normal share to the blood of prosperity. Combat and danger bring death to a considerable proportion. The rest are outside the pale of regular family life. In trading posts, in mining towns, along the frontiers, males are largely in excess; and they are relatively barren. The influence of this selective factor, coupled with the results of military selection, can hardly be over-emphasized. From the loins of the "stay-at-homes" come succeeding generations. The prophecy has been fulfilled; the meek have inherited the earth.

It may be worth while to notice more particularly the effects of military selection, especially because the peace advocates have recently, in their attempt to make out a strong case against war at this point, quite effectively muddled the subject. Possibly the persistence of the military organization, involving the continuous recruiting of a professional military class, alongside of the waxing industrial organization, is the most conspicuous fact in history. Selectively, the question to be asked is: what sorts of men have perished in war? Who marched away? The one patent answer is: not those who were the most peaceably inclined. The factors are, of course, complex; but military selection has

drained, on the whole, neither the best nor the worst of the racial stock, but has been an outlet for the intractable members of society. Wild, ungovernable boys, hoodlums in the making, men with the blood-lust still strong in them—such have joined the army and entered the navy through the centuries. The great mercenary forces, recruited so long throughout Europe, did not deprive civilization of men in whom the social virtues were strongly marked. The professional military class has always absorbed—and utilized to advantage, indeed—the men that in the freedom of a purely commercial régime would have been so much explosive material.

This is not to deny, it is admitted, that war has often resulted in retrogression through unfavorable selection. But the peace advocates reveal the one-sidedness of their argument by a too frequent appeal to examples of revolution and internal rebellion, like the French Revolution and the Civil War in the United States, where members of the superior and ruling classes were lopped off, or where enormous masses of enthusiastic volunteers were enlisted from the citizenship. If war had committed such ravages in the human stock as these pacificists maintain, it might be supposed that there would have been a decline in the fighting force of civilized men. But the very opposite is true. Modern men are braver and steadier, make better soldiers, than did the men of antiquity.[7] The reason is that the same moral qualities which have been selected through the elimination of the anti-social, are, in part, the virtues which make the best armies—such virtues as obedience, the habit of discipline, self-control and steadfastness. And, curiously enough, in the breeding out of the opposite qualities, the predatory disposition, irresponsibility and refractoriness, the unbroken existence of the military organization has played its part.

Another prominent factor in socialized selection comes under the head of vice and racial poisons. No argument is required to prove that persons who indulge in sexual excesses, in drunkenness, in drug habits, in debauchery of any kind, are anti-social, lacking the moral stamina which would make them, say, self-supporting individuals contributing their share to the social income. Our point is that vice, in the degree of indulgence, is also eliminative. Sexual excesses, for example, sap energy, weaken resistance to disease, and predispose to early death. The more licentious a man or woman, the greater are his or her chances of contracting a venereal disease. Gonorrhea and syphilis, where they do not kill, tend to sterilize. Consequently those who can not, through lack of self-control or excessive lust, conform to social and ethical standards of purity, cripple themselves in reproductive power. Prostitutes, a big population in every country, every age, bear few, if any, children.

[7] "Physics and Politics," p. 47.

Alcohol and the other narcotics produce much the same results. On the question as to what extent drunkenness is due to flabby moral fiber, there has been dispute. Archdall Reid declares[8] that alcohol taken to excess is an "agent of elimination at once selective and very stringent. It weeds out great numbers of individuals of a particular type—those most susceptible to its charm." This authority thinks moral resistance to alcoholic temptation of small consequence; men, he says, "indulge in it in proportion to their desires." On this point there is naturally much dissent, but there is no need that we enter the controversy. Certain men are swamped by alcohol and other men left. In so far as the moral factor determines the incidence of this selective force, we have elimination of the anti-social.

Finally we may note one more agency which works for the increase of social tractability. The various factors we have mentioned so far have been mainly phases of lethal selection; now we turn for a moment to sexual and reproductive selection. In every generation there are persons who are debarred or abstain from wedlock. Among the men who enter matrimony a certain proportion desert their wives or are divorced. There is, further, a wide-spread practise, rapidly growing in our day, of placing voluntary restraints on child-bearing.

Now persons who do not mate with the opposite sex, or mated, refuse to have children, are sometimes those whose social sympathies are feeble. The domestic virtues are the social virtues par excellence. We could never breed a race of misogamists, nor are we in any danger of populating the earth with a race of women militant against men. Along with many other results we perhaps have here some elimination of the anti-social. But we do not care to stress this point. The motives which lead to voluntary childlessness are numerous and mixed, and the final influence on the racial inheritance seems most disastrous, since it substantially results in a continuous sterilization of the better stocks. All things considered, this is the gravest difficulty that the eugenists have to face.

III

The foregoing hasty summary of the more important factors which have conferred survival value on altruism and tractability has, it is hoped, given some appearance of solidity to the contention that there has been a steady elimination of the anti-social throughout historic times. It is not argued that we have here an explanation of all the moral differences between the civilizations of antiquity and of the present. The increments of knowledge, the growth of cohesive social and political institutions and the betterment of economic conditions, have all played a part in knitting the moral fabric of the world of

8 "The Principles of Heredity," p. 195.

to-day. Nevertheless, the centuries spent in purging the primitive from the race have contributed to the result. Undoubtedly, too, this agency will continue to operate in the future, although with what modifications it is hard to predict.

Patently it is impossible to weigh statistically the effect of the many criss-cross forces which have molded nations, or to reconstruct with accuracy the historical process. Both the men who perished and the men who survived are now gone beyond recall. It might be suggested that we could make a "control test" by analyzing the mental characters of contemporary savages, who are often said to be close replicas of our own barbarian ancestors. We might, provided we had the psychological method at hand, make enough mental tests to define a type-barbarian. In similar wise we might be able to define a civilized type. Then by comparing the two we could determine what were the inherent moral differences between them. But there are unsurmountable difficulties in this procedure. We have not the psychological method as yet to work with, and after the work had been accomplished we could not be sure that the savages whose natures had been charted were in truth identical with the ancients from whom civilized men are sprung. We should, moreover, become entangled in the questions of racial differences—why, for example, some savage peoples, like the Papuans, the Aleuts and the Dyaks, are so amiable, while other savages, such as the North American Indians and the Gonds, are bloodthirsty; or why the ancient Egyptians were apparently less cruel than the ancient Assyrians. In our discussion of selective agencies attention has been directed chiefly to the development of the Aryan peoples.

One test of a logical nature is available. If we grant the validity of socialized selection we find an immediate explanation of the paradox which has puzzled former commentators on the dissimilarities of the classic and modern cultures. We can now understand why it is that there has been an enormous increase of kindliness, of steadiness, of "prescriptive governability," despite the fact that early civilizations were quite as prolific of eminent men of the highest intellectual and moral caliber.

As we said earlier, confusion has been wrought by looking for moral improvement where there has been only moral change. A growth in human meekness may very naturally have been accompanied by a decline in a certain splendid turbulent virility possessed by our ancestors. When this selective instrument made men more sympathetic, it may also have made them less daring. David Starr Jordan remarks:[9]

> If France, through wine, has grown temperate, she has grown tame. "New Mirabeaus," Carlyle tells us, "one hears not of; the wild kindred has gone out with this, its greatest."

[9] "The Human Harvest," p. 69.

To get altruism we have sacrificed the higher, intenser type of energy; and the cowboy, the soldier and the haughty aristocrat typify the passing virtues of the race. There is a great deal of pregnant meaning in the assertion of William James that the world is evolving into a middle-class paradise.[10]

> An irremediable flatness is coming over the world. Bourgeoisie and mediocrity, church socials and teachers' conventions, are taking the place of the old heights and depths and romantic chiaroscuro. . . . The higher heroisms and the rare old flavors are passing out of life.

Along with this probable decline in energy and intensity, it must be remembered that the elimination of the anti-social has never conferred survival value on originality, on intellectual independence, on path-breaking initiative, or on genius. In fact the very agencies which conserved sociability were the ones which cut down inventive capacity. No force has been at work to increase the racial store of eloquence, poetic imagination, of musical and mathematical ability; so that, while there has been a progressive selection of the fundamental moral qualities, there has perhaps at the same time been a deterioration in the esthetic endowment.

It is plain, then, why individuals of the noblest intellectual and moral qualities appeared as often in early civilizations as among the millions we spawn to-day—why, as James Bryce phrases it,[11] those rare combinations of gifts which produce poetry and philosophy of the first order "are revealed no more frequently in a great European nation now than they were in a Semitic tribe or a tiny Greek city twenty-five or thirty centuries ago." Nothing which the human mind exhibits at present has been added by nature since the dawn of history. The esthetic and intellectual powers were then in as full, if not fuller, bloom, as now, being, as Weismann points out, by-products of the human mind, which had been "so highly developed in all directions."[12] The average man in those times was, we may safely assume, more brutal and flightier than the average man of to-day, but he probably possessed a larger store of native ability, more of sheer mental energy.[13] Selection, through the elimination of the anti-social, has whittled us down, so to speak, to fit our civil environment, cutting away our intellectual strength and our moral weakness with the same strokes.

This is the reason that it is unsafe to argue from the exceptional man to the average man. The exceptional man, in the nature of the case, exhibits a combination of the higher ethical and intellectual traits.

10 "Talks to Students on Some of Life's Ideals."

11 "American Commonwealth," Vol. 11, p. 768.

12 Lecture on "Heredity."

13 This is quite in accord with Galton's calculation that the average ability of the Athenian race was nearly two of the mental grades higher than that of present-day Englishmen. "Hereditary Genius," p. 330.

In him the native harshness of the race is disguised. Alfred Russel Wallace, because of the clarity of his reasoning, betrays the precise manner in which one falls into the mistake of supposing great men to be a racial barometer. He declares:[14]

> Tolstoy can hardly be ranked as higher than Buddha, or Ruskin than Confucius, and as we can not suppose the amount of variation of human faculty about a mean to be very different now from what it was in that remote era, we must conclude that equality in the highest implies equality in the mean, and that human nature on the whole has not advanced during the last three thousand years.

Wallace did not realize that in some particulars the highest may seemingly, at the distance of thirty centuries, belie the mean.

Selection has had an almost infinite variety of human material to work on—all sorts of combinations between intellectual powers and moral excellencies. What selection has apparently done, through those agencies we have denominated the elimination of the anti-social, is to knock apart the two sets of endowments, and to recombine them in ways which give us, speaking broadly, a general average of greater moral stability linked with lesser innate talent. Civilization, in bending human nature to its wheel, has softened it and at the same time crushed out some of its virgin vigor.

[14] Essay on "Evolution and Character."

EPHEMERAL LABOR MOVEMENTS, 1866–1889

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THE history of labor organizations (1866–1889) is a record of ebb and flow, agitation, organization and disintegration. It is, indeed, a strange blend of unionism and politics, of individualism and socialism, of strikes, greenbackism and cooperation, of prosperity, panics and concentration of industry. This quarter of a century is preeminently one of preparation; in it are laid the economic and psychological foundations upon which have been built, in a large measure, the trade-union organizations of to-day. Movements, ephemeral and incohoate, but grand in conception, hasten nervously across the stage. At intervals during the period writers in the numerous labor papers declare that now is a time of transition and that organization at this particular moment will be unusually fruitful of good results. The workers, distrustful and individualistic but harassed by the fear of monopoly, the competition of unskilled labor, the introduction of machinery and lower wages, cohere for a brief period under the pressure of extraordinary conditions or the influence of enthusiastic leaders, only to repel each other as their financial skies appear to clear. But, by the end of the period, the labor organization had become one of the permanent institutions of the nation.

When the civil war ended labor organizations of the trade-union type were multiplying and waxing stronger. The return of the soldiers to peaceful pursuits, the continued influx of immigrants from the old world, and the growing power of industrial combinations, all contributed to arouse the wage earners of the nation to activity. The years 1866 and 1867, probably represent the period of maximum activity during the era immediately following the surrender at Appomattox. In 1864, an unsuccessful attempt had been made to organize a national federation of trade unions. Two years later the National Labor Union was organized at a National Labor Congress held in Baltimore. This was the first successful national federation of trade unions formed since the National Trades' Union disappeared in 1837. In 1865, a state federation of trade unions was organized in New York—The Workingmen's Assembly. This continued until merged in 1897 with the state organization affiliated with the American Federation of Labor. Its chief purpose seems to have been to influence legislation. "The distinctive features of the organization are Protective, Benovelent and Secret."[1] In the early years of the Assembly, nearly all of the affiliated

[1] Proceedings of Fifth Annual Session, January, 1869.

bodies were protective, many benevolent, and at least two were secret—The Supreme Mechanical Order of the Sun and the Knights of St. Crispin. In 1869, the assembly favored the establishment of cooperative enterprises; but little progress was reported for the year 1868. At the close of that year there were at least six cooperative foundries in the state.

The Workingmen's Union of New York City and vicinity, "reorganized in 1864 and incorporated in 1866," was a city central labor union. All representatives sent to this central body were required to be "practical" workingmen actually working at their trade. The objects of the union were to unite the strength of different organizations in the city, to foster a friendly feeling between workingmen, to discuss and modify proposed legislation, to adjust difficulties between labor and capital—accepting the "axiom, That the interests of labor and capital should be identical,"—to discountenance strikes except when "they become absolutely necessary." Evidently class consciousness was not as yet highly developed among the organized workingmen of our largest city.[2] A very interesting preamble to the constitution of The Stair Builders' Mutually Protective and Benevolent Union of New York City offers further evidence. The Stair Builders deplored the concentration of wealth in the hands of the few. They asserted in italics that the "interests of the employee and the employer are identical." But they also declared "the independent and irresponsible action of individual employers ignores the claims and rights of employees, casts upon the field of labor incompetent workmen, lowers the dignity of the mechanic, and degrades labor." Through union action they hoped to advance the interests of labor and to secure their just reward.[3]

In 1868, at least twelve national and international trade unions were in existence: International Union of Bricklayers, Plasterers' International Union, Carpenters' National Union, National Typographical Union, Moulders' International Union, International Union of Machinists and Blacksmiths, Coach Makers' International Union, Ship-carpenters and Caulkers' International Union, Brotherhood of Locomotive Engineers, Glass-Bottle Blowers' Association, Cigar Makers' International Union, Knights of St. Crispin. The Daughters of St. Crispin was organized in 1869; and was the only women's trade union having a national organization. One authority states that more than thirty national trade unions were in existence during the decade, 1863–1873.[4]

The President of the New York State Workingmen's Assembly reported a membership of 280 organizations in January, 1868, and 305

[2] Laws, Rules and Regulations, issued 1867.

[3] Constitution and By-laws, printed in 1869.

[4] Andrews, "Report on the Condition of Woman and Child Wage Earners in the United States," Vol. 10: 89.

one year later. The assembly was said to represent 25,000 working people. Five unions in New York City were reported to contain a membership of at least 1,000 persons each. These unions were: Typographical Union, No. 6, 2,300 members; Longshoremen's Society, No. 2, 2,300 members; Bricklayers' Union, No. 2, 1,600 members; Cigar Makers' Union, No. 90, 1,250 members; United Cabinet Makers' Union (German), 1,000 members.[5] In the year 1867, thirty thousand was "not an extravagant estimate of the actual strength of the labor organizations in New York" City. Brooklyn, Jersey City, Newark and the Westchester towns were estimated to contain 20,000 additional union men.[6] At the annual meeting of the Bricklayers' International Union in 1867, it was reported that the national body contained 24 unions in good working order. One year previous, the number was only ten.

As has been indicated, with the return of the soldiers looking for employment, the rising tide of immigration, the greater use of labor saving devices, and the growing strength of corporate organizations, the need of greater solidarity and unanimity of action among the working people was felt sufficiently to enable a national federation to be formed and continued for a few years. Like the pioneer national federation of trade unions organized in the thirties, the National Labor Union was merely an advisory body; it never attained much strength or prestige. William H. Sylvis, one of America's ablest labor leaders, was an important factor in initiating and building up this organization. Mr. Sylvis was elected president of the National Labor Union in 1868.

From its inception political activity seems to have been an important part of the work of the National Labor Union. In fact the chief aim and purpose of the organization was political rather than purely industrial. The first congress, held in 1866 at Baltimore, recommended that steps be taken to form a national labor party "which shall be put in operation as soon as possible."[7] Again, in 1867, it was resolved that the time had arrived when "the industrial classes should cut themselves aloof from party ties and predilections and organize themselves into a National Labor Party." In the first congress much stress was laid upon the necessity of organizing trade unions; but, in 1868, a resolution was adopted stating that "the very existence of the National Labor Union depends upon the immediate organization of an independent labor party."[8] The greenback issue and the opposition to national banks first received official recognition in 1867. Doubtless those two issues were raised at that time because of the depression which

[5] Proceedings of the 5th Annual Session (1869).

[6] *New York Tribune,* April 30, 1867; also in "The Labor Question," a collection of articles published in 1867.

[7] "Documentary History of American Industrial Society," Vol. 9: 137.

[8] *Ibid.*, p. 204.

followed the close of the war and because of the demand that the greenbacks be retired. Contraction of the currency was checked by act of congress in 1868.

An influential element within the National Labor Union favored affiliation with the International Workingmen's Association; but it never united with this socialist organization. In 1870, a resolution was adopted in which the National Labor Union "declares its adhesion to the principles of the International Workingmen's Association, and expects at no distant day to affiliate with it."[9] The National Labor Union as an organization can not, however, be said to have been class conscious.[10] Substantiating this statement is the fact that delegates were admitted to the annual meetings from organizations other than those of workingmen. In 1866 delegates from Eight-hour Leagues, Land and Labor Reform Unions and Anti-Monopoly Associations were admitted. At the annual congress in 1870 a representative from a farmers' club was seated. It is also worthy of mention that at this congress a representative of the National Guard of Industry and one from the Colored Teachers' Association of Cincinnati were given seats. Nevertheless, at the congress of 1869, Miss Susan B. Anthony was rejected as the delegate of the Working-women's Protective Association, on the ground that it "was not a *bona fide* labor organization." [11] The credentials of Mrs. Elizabeth Cady Stanton as a representative of the Woman's Suffrage Association were accepted in 1868—because she came from an organization for the "amelioration of the conditions of those who labor for a living."

After the death of President Sylvis in the summer of 1869, only a few days before the annual meeting, the National Labor Union began to show unmistakable signs of weakness. The editor of its official organ, *The Workingman's Advocate,* of Chicago, pointed[12] to the apathy of the workingmen as an alarming sign of the times. The officials were not receiving that essential of all organizations, financial support. On January 29, 1870, appeared an editorial in regard to the union under the caption, "To Be or Not To Be." In March, the president issued an urgent appeal for funds. Since the preceding summer only $448 had been received by the treasurer of the organization from all sources.

The Congress of 1871 decided to divide the political and industrial activities; and it authorized calls for two conventions for 1872—the National Labor Party and the National Labor Union. It was the convention of the former which nominated David Davis for president in 1872. The last Congress of the National Labor Union was held in

[9] "Documentary History of American Industrial Society," Vol. 9: 268.

[10] See Hillquit, "History of Socialism in the United States," p. 193.

[11] "Documentary History of American Industrial Society," Vol. 9: 231. Miss Anthony was seated in 1868.

[12] *Workingman's Advocate,* December 11, 1869.

1872. It was of little importance; but steps were taken leading toward the organization of a "National Industrial Congress." Nevertheless, as late as March 24, 1874, *The Workingman's Advocate* still called itself "the official organ of the National Labor Union."

The first National Industrial Congress was held in Cleveland, July 15, 1873. The only labor organization which opposed the movement was the ever-conservative Brotherhood of Locomotive Engineers. The leaders of the new movement proposed to steer clear of politics. No constitution was adopted in 1873. Robert Schilling, of Ohio, was chosen as its president. Some of the resolutions adopted savored somewhat of political activity; and later some opposition developed because of the adoption of these resolutions. But the call for this congress stated definitely that steps would be taken to prevent it from deteriorating into a political party.[13] Evidently the leaders of the Industrial Congress believed that politics had wrecked the National Labor Union; and that a stronger national federation of trade unions was desirable. The second congress was held at Rochester, April 14, 1874. Many of the delegates were men who had been prominent in the National Labor Union. A constitution was adopted and the name Industrial Brotherhood was assumed. The declaration of principles was almost the same as that later adopted by the Knights of Labor.[14] Many of the demands were political rather than purely industrial. Its platform viewed with alarm the aggression of aggregated wealth, which, it was urged, tends toward the degradation of the masses.

Although Mr. Powderly[15] is of the opinion that a third congress was not held, there is evidence that a National Industrial Congress was held at Indianapolis on April 13, 1875.[16] In its declaration of principles, appeared a clause opposing the use of the military power against striking workingmen. *The Workingman's Advocate* became in due time the "official organ of the National Industrial Congress"; and as late as October 13, 1877, it still used this title. Although the Brotherhood or the National Industrial Congress was organized by trade-union men, it was somewhat like the Knights of Labor in principle. Trade unionists objected to the organization of locals under the auspices of the Industrial Brotherhood; and they also were adverse to associating with unskilled labor in an organization. This attitude on the part of the skilled men and the continued industrial depression following the panic of 1873 destroyed the organization.[17] The early death of the Industrial Congress indicates that the National Labor Union was not

13 *Workingman's Advocate,* May 3, 1873.

14 Report of the Industrial Commission, Vol. 17: 3.

15 "Thirty Years of Labor," p. 126.

16 Files of *The Workingman's Advocate,* 1875.

17 Powderly, "Thirty Years of Labor," p. 126.

destroyed solely because it went into politics, but chiefly because the industrial development of the country was not sufficient to weld the workingmen of the nation into a strong and permanent federation. They could see no excellent reasons for paying dues to such an organization—except during a time of stress. The National Labor Union and its successor, the National Industrial Congress, died of financial weakness and the apathy of their members.

In 1876, another attempt was made to form a national federation. A call was issued by an "executive committee" from Pittsburgh, January 5, 1876, "To all Labor Orders, Unions and Associations of the United States." Delegates were asked to be "prepared to take such steps as will place our now scattered forces under one organized movement, for immediate action, to get and to hold, and use the balance of power. . . . The issue is a labor issue, an issue of the right of men to 1876. The social democrats tried in vain to commit it to the policy of organizing a distinct labor party. A substitute plan was adopted which is quite similar to the more recent plan fathered by President Gompers of the American Federation of Labor.

> *Resolved:* That independent political action is extremely hazardous and detrimental to the labor interests; that the workingmen of the country should organize into trades unions and labor leagues to educate the people first,

and endeavor to elect men in both parties favorable to the interests of the wage earners.

The editor of a labor paper complained in 1877:

> All our national organizations for the unification of labor are dead. Labor is divided in a thousand unions and factions.[19]

He declared that employers and employers' associations were bitterly fighting labor and that the next necessary step in the struggle against combinations of capital was a "National Federation of Trades' Unions." During the last years of the seventies, such national unions as the Amalgamated Association of Iron and Steel Workers of the United States, the International Typographical Union, and the Cigar Makers' International Union were agitating the matter of a national federation. In 1881, the President of the Typographical Union wrote in his annual report:

> The subject is of such importance that we can afford to suffer in patience numerous failures if as an ultimate result the mechanics of the United States and Canada can be brought into a closer and common organization for the common good.

There is much evidence indicating that the far-sighted labor leaders of the seventies saw the need of a permanent national federation of trade unions. On November 15, 1881, at Pittsburgh, was formed the Federation of Organized Trades and Labor Unions of the United States

[19] *National Labor Tribune*, April 7, 1877.

and Canada. This organization in 1886 voted to merge with other trade unions and the name, American Federation of Labor, was adopted.

In addition to the trade unions of the period, such as the International Typographical Union and the Cigar Makers' International Union, and the national federations, such as the National Labor Union and the Industrial Congresses, the Knights of Labor and numerous ephemeral labor organizations appeared whose ideal was that of "one big union." Like the Knights of Labor these organizations practically ignored trade lines. Except in the case of a few controlled by the socialists, they were in reality reform associations composed chiefly of wage earners. These ephemeral organizations are interesting chiefly because they throw some light upon the conditions of the period and upon the ideals and demands of the wage earners. The decade of the seventies was especially prolific of ephemeral labor-reform associations.

The National Guard of Industry was organized in 1869. It admitted "all trustworthy persons who earn their bread by the sweat of their brow" and who are friendly to its purposes. The platform of the order was a peculiar hotch-potch of humanitarianism, trade unionism and political reform; it favored the eight-hour day and cooperation, and opposed granting land to corporations.[20] The "early closing movement" is not of recent origin. As early as 1866 or 1867, in New York City, a "Dry Goods Clerks' Early Closing Association" was in existence. The Supreme Mechanical Order of the Sun was established in the early sixties. It was still in existence in 1869, a secret order having an extensive ritual and several degrees.

In 1872, the Christian Labor Union was formed for the purpose of influencing the Church to aid in the establishment of cooperative associations. The Association of United Workers of America, called by Professor Commons the "nationalized International," came into being in 1874, and was apparently merged into the Workingmen's Party two years later. It was a socialist organization. Each member was expected to support only those political movements which aimed directly at the economic emancipation of the wage earners.[21]

The Junior Sons of '76 "do not attribute all our suffering to any single cause, but to a variety of causes." They appealed to all workers to unite "against the growing power of monopolies" by using the ballot. Laboring men should be elected to office. The Junior Sons was a secret organization supposed to be composed exclusively of workingmen. In the spring of 1875, it was stated that in several counties of Pennsylvania the majority of the voters were members of

[20] Pamphlet in New York Public Library.

[21] General Rules, published in 1876.

the order.[22] The Order of American Mechanics admitted only native-born persons.

One of the most unique and most powerful of the ephemeral organizations was the Sovereigns of Industry, established in 1874. It was a secret order which admitted both men and women. According to the preamble of the organization's constitution, it was "an association of the industrial working classes without regard to race, color, nationality or occupation; not founded for the purpose of waging any war of aggression upon any other class, or fostering any antagonism of labor against capital, nor of arraying the poor against the rich, but for mutual assistance in self-improvement and self-protection." The sovereigns repudiated the subsistence theory of wages, and proposed to increase real wages by reducing expenses through cooperation. The ultimate purpose seemed to be the elimination of the wage system. They proposed to "make war on the middleman as the exclusive remedy for the ills of the workers." The sovereigns did not propose to displace any existing labor organization. In the spring of 1875, it was estimated that over 50,000 Pennsylvanians belonged to the order.[23]

The International Labor Union was organized in 1877 with George E. McNeill as president.

> In this hour of the dark distress of labor, we call upon all laborers of whatever nationality, creed or color, skilled or unskilled, trade unionist and those now out of union, to join hands with us and each other to the end that poverty and all its attendant evils shall be abolished forever.

The chief objects of the union are indicative of the important demands of the labor reformers in 1877: reduction of the hours of labor; higher wages; factory, mine and shop inspection; abolition of the contract convict labor and truck system; employers to be held responsible for accidents to employees on account of the neglect of employers; prohibition of child labor; establishment of labor bureaus. Although branches are reported to have existed in seventeen states, the membership was small. The union attained its greatest strength in 1878.[24]

As early as 1866, organized labor began timidly and intermittently to enter the political field. Editor Cameron of *The Workingman's Advocate,* perhaps the leading labor paper of the period and the official organ of the National Labor Union, was nominated as a candidate for a seat in the lower house of the Illinois legislature, by the workingmen of Chicago. The editor of the *National Workman,* the official organ of the federated trades of New York City, wrote (January 5, 1867):

[22] *National Labor Tribune,* April 24, 1875.

[24] McNeill, "The Labor Movement," pp. 161–162.

[23] *National Labor Tribune,* April 24, July 31, October 23, 1875.

The New Year opens with flattering auspices to the cause of labor reform. Many governors of states and members of state legislatures have been elected upon the workingmen's tickets, as friends of the eight-hour system.

The first Congress of the National Labor Union (1866) declared that only candidates favorable to an eight-hour law should be deemed desirable by the workingmen of the country. In 1867, at least three states, New York, Connecticut and Michigan, held workingmen's conventions; and a National Labor Reform Party seems to have been organized. In a platform adopted August 22, 1867, it opposed national banks. The "money monopoly" was held to be "the parent of all monopolies." The issuance of treasury notes was recommended as a preventive of growing inequality in the distribution of wealth. Land monopoly was feared; and as a remedy for insufficient employment, it was urged that workers proceed to the public lands and become actual settlers. The platform contained a clause favoring cooperation; and strikes were deprecated. A demand was made for improved dwellings and tenements for workers.[25] This party undoubtedly died soon after its birth, because William H. Sylvis, upon being elected president of the National Labor Union in 1868, urged the organization of a workingman's party, and the congress voted to organize a "labor reform party."

The leaders of the labor movement in the late sixties often deplored the rottenness which prevailed in partisan politics.

It is a sad day for the people when such rottenness prevails in the Senate; when knavery rules the House; when pampered debility occupies the presidential chair, and cabinets are composed of corrupt politicians or political ingrates. . . . The laboring man of to-day in America whatever he may be theoretically, is practically a *paria* and a slave, at the mercy of corrupt swindlers, under the guise of respectable capitalists.[26]

An address of the National Labor Union, issued in 1870, declared that the whole country was under "the supreme control of bankers, moneyed men and professional politicians." The editor of *The Workingman's Advocate* urged the formation of a "Great Peoples' Party." At this time "money and monopoly" were repeatedly mentioned as menaces to free government.

In 1870, the National Labor Congress voted to take independent political action throughout the country. It was stated that the two old parties would not join hands with labor and would not accept the platform of the National Labor Union. The workers did not rally to the support of the labor candidates. After the election, the editor of *The Workingman's Advocate* declared with some bitterness that the labor-reform candidates had been overwhelmingly defeated—and by the workers themselves. The candidates, it was stated, "were for the most

[25] *Workingman's Advocate,* September 12, 1868.

[26] Letter written by H. H. Day, member of executive committee of the N. L. U., to Senator Henry Wilson, *Workingman's Advocate,* June 19, 1869.

part representative trade unionists." The Congress of 1870 also authorized the appointment of a committee to issue a call for a national convention. It was issued soon after a meeting of the committee, held January 17, 1871.

This call is worthy of brief notice. It confidently asserted that capital was master in the United States. The instrumentalities which gave capital its favorable and dominating position were enumerated under five heads:

1. Banking and moneyed monopolies.
2. Consolidated railways and other traction monopolies.
3. Manufacturing monopolies which crushed the small operators and determined the wages of the workers.
4. Land monopolies—the result of the absorption of the public domain by a few corporations.
5. Commercial and grain monopolies which indulge in speculation.

The first and fourth points were not new or especially significant. The outcry against banks dates back to the time of Jackson or before that era. During the forties and fifties much opposition was manifested against land monopoly.[27] This call was, however, directed specifically against the policy of giving land to railways. But the remaining three points are of more significance; new foes are now feared by the wage earners of the country. Consolidated railways, manufacturing, commercial and grain monopolies are represented as inimical to the interests of the wage earners; and the call favored the regulation or abolishment of corporate monopolies. The editor of *The Workingman's Advocate*[28] asserted that "centralization and labor" are two antagonistic elements.

A labor-reform party was organized in Massachusetts in 1869; and in that year it elected twenty-one representatives to the State Assembly and one state senator. The state ticket polled 13,000 votes. In the following year, Wendell Phillips was nominated for governor. The party advocated the separation of industrial from political questions. Two new and significant demands are found in the platform: the regulation of railway rates and the abolition of the importation of laborers, particularly from China, under contract. In 1871, the resolutions presented by Phillips and adopted by the labor-reform party were tinged with socialism. It was affirmed that labor is the creator of all wealth; the abolition of special privileges was demanded; and it was asserted that the capitalistic system was making the rich richer and the poor poorer.[29]

An attempt was made, in 1872, to put a national ticket in the field.

[27] See article by the writer in *Quarterly Journal of Economics*, February, 1910.

[28] July 15, 1871.

[29] Carlton, "The History and Problems of Organized Labor," p. 61.

David Davis of Illinois was nominated for president and Joel M. Parker of New Jersey for vice-president. Neither of the gentlemen were workingmen. Both withdrew a few weeks later; and no further nominations were made. Two years later, independent reform candidates were nominated in Illinois and, perhaps, elsewhere. In 1875, the editor of *The Workingman's Advocate* was interested in the Greenback Party.

Undoubtedly many members of the National Labor Union who were committed to political action and opposed to the "money monopoly" became members of the Greenback Party. Others who were more radical turned to the Workingmen's Party of the United States. In other words, the small but aggressive class-conscious element within the National Labor Union joined the latter party; and the element which stood for reform affiliated with the Greenback movement. Those who joined the Greenback Party adopted the philosophy of the small proprietor and the skilled artisan; but those who united with the Workingmen's Party and later the Socialist Labor Party, adopted the economic theories of Karl Marx. The Greenbackers did not propose to do away with private ownership of capital; they only desired to prevent the concentration of capital in the hands of a few large capitalists. The Greenbacker was a reactionist rather than a progressive; he wished to prevent the growth of monopoly and large-scale industry. His viewpoint was that of the pre-Civil-War period; he looked backward instead of forward. Consequently, the Greenback movement is much more closely related to anarchism than to socialism.[30]

The American workingman of the generation immediately following the Civil War was still saturated with the philosophy of the frontier or of Jacksonian democracy; he as yet accepted the oft-repeated, and not-frequently contradicted, dictum that each and every wage earner had an excellent opportunity to become a small proprietor or even a captain of industry. As long as this situation obtained, it was not difficult for "pure and simple" trade unionism generated in a period of stress and of rising prices like the last years of the Civil War, to be gradually transmuted into "labor reformism" and "greenbackism." The greatest labor organization of the period under discussion, the Knights of Labor, was primarily a reform association. The ultimate aim of its leaders during its years of growth was some form of a cooperative commonwealth. Its famous preamble was taken almost verbatim from one drawn in 1874 for another organization, by George E. McNeill, the "Apostle of the Eight-hour Movement." But hard times, unemployment, the disappearance of the famous westward-moving frontier line, the rush of immigrants from Southern Europe, the consolidation of capital, and the failure of sundry reform movements were preparing

[30] For a statement of the theory of greenbackism, see "Documentary History of American Industrial Society," Vol. 9: 33–43.

the way for the development of permanent trade unions. During the decade of the eighties were organized over one fourth of the national trade unions considered by the Industrial Commission in 1901; but only about one in every six were organized before 1880. Or, less than one half were in existence prior to 1890.

Likewise the socialists were not strong before 1890. The "German period of socialism in the United States" ended about 1876.[31] The International Workingmen's Association formed its first American section in 1871.

> By 1874, the attempts to internationalize the American movement were abandoned, and in that year a nationalized International, the United Workers of America, was attempted.[32]

and several local socialist parties arose. In 1876, several organizations of socialists, including the United Workers, were united to form the Workingmen's Party of the United States. One year later the name was changed to Socialist Labor Party. At first the Socialist Labor Party advised its members not to take part in political campaigns; and, although interested in several local campaigns, epecially in New York City and Chicago, it did not put a presidential candidate in the field until 1892. In 1886, however, the Socialist Labor Party of New York united with the single taxers and certain labor organizations to support Henry George for mayor on the United Labor ticket.[33] The socialists joined, in 1878, with the labor reformers to form the International Labor Union.

Another International Workingmen's Association was organized, in 1881, composed of American workingmen and farmers. It was strongest in the west; but soon disbanded. Two years later, the International Working Peoples' Association was formed. In this organization the anarchists were in control.[34] The local socialist labor party in Chicago, which polled about 12,000 votes in the city election of 1879, and elected three aldermen,[35] was soon broken into factions. One portion supported General Weaver of the Greenback ticket in 1880. Another faction influenced by the teaching of anarchists, began to doubt the wisdom of political action.[36] In recent years, the direct-actionists of the Chicago branch of the Industrial Workers of the World seem to constitute a type of socialists similar to the American Internationalists of the eighties. In each case, the value of political action is depreciated, revolution and direct action are emphasized, and a tendency toward anarchism may be discerned.

The panic of 1873 and the five years of depression following the

31 Hughan, "The Present Status of Socialism in the United States," p. 34.

32 "Documentary History of American Industrial Society," Vol. 9: 46.

33 Hughan, *ibid.*, p. 38.

34 Ely, "The Labor Movement in America," Ch. 9.

35 One was also elected in 1878 and again in 1880.

36 Schilling in Parson's "Life of Albert R. Parsons."

panic forced many unions to disband. It was a period marked by an extraordinary amount of unemployment, unrest and suffering, by reductions of wages, and by strikes and lockouts.[37] In the later years of the period, many secret organizations of workingmen appeared. In the spring of 1874, a writer in a labor paper asserted, doubtless with some exaggeration, that "to-day there is not a Trade or Labor Union in existence but gives the greatest publicity to its aims and objects."[38] It was intimated that opposition on the part of employers would cause secret unions to spring up. One year later, the *National Labor Tribune* contained an editorial entitled, "The Spread of Secret Orders"—meaning labor organizations.[39] Pinkerton, the detective, writing in 1878, asserted that there were scores of secret labor organizations.[40] Labor difficulties culminated with the railway strikes of 1877. These were precipitated by cuts in wages. The year 1879 ushered in a more prosperous period.

The two quotations following represent fairly well the attitude of the discontented wage earners in 1876, the centennial year.

> Symbolize if you can the American laborer of 1876. Show him as he is, without liberty of thought or action, oppressed, cheated, trodden on, vilified by press and public opinion, condemned by the pulpit and the platform, reduced to serfdom by a combination of capitalists and monopolists; bring such a picture among your grand paintings, produce such an image among your statuary, and look on this picture and then on that, and ask what has the public of America accomplished for the cause of humanity.[41]

The chairman of an "Immense Mass Meeting of Workingmen" held at Cooper Institute, June 17, 1876, under the auspices of the Independent Labor Party, declared:

> The lands, the money, the property of the nation have passed into the hands of the few, and the many are idle, homeless and starving.

The agitation and unrest among the workers led to repressive measures on the part of various city officials.

> On the announcement of public meetings of the unemployed, the conscience-pricked communities took alarm and feared that the bringing together of so many heretofore patient sufferers might imperil their lives and property. From the earliest days of the agitation of the question of the relations of labor and capital, free speech had often been restrained and sometimes forbidden. This had been especially true in those smaller towns and manufacturing centers.[42]

In New York City, the city officials revoked a permit to hold a meeting of laboring people in Tompkins Square, and drove out the people who came to attend the meeting. This was frequently referred to as "The Tompkins Square Outrage."

37 Rhodes, "History of the United States," Vol. 7: 52–53.
38 *Iron Moulders' International Journal,* quoted in *The Toiler,* June 27, 1874.
39 April 24, 1875.
40 Pinkerton, "Strikes, Communists, Tramps and Detectives," p. 89.
41 *National Labor Tribune,* April 24, 1875.
42 McNeill, "The Labor Movement," p. 147.

In the soft coal fields, after a strike in 1875 caused by a reduction in wages, two of the strike leaders, John Siney, president of the Miners' Union, and Zingo Parks were arrested for conspiracy. Siney was acquitted; but Parks was sent to the penitentiary.[43] The famous "coal and iron police" was organized at this time. The union among the miners was practically destroyed, and soon the "Molly Maguires" appeared as the natural product of a policy of repression.

The pressure of hard times caused the membership of the International Typographical Union to decrease from 9,797 in 1873 to 4,260 in 1878; and the number of unions in the organization declined from 105 to 60. In 1877, unionism among cigarmakers "was almost extinct." Only 17 unions remained in good standing in the International Union. Outside of New York City, Chicago and Detroit there were only 217 union cigarmakers in the United States and Canada. The strikes of 1877 are said to have acted as an "alarm bell." There were over six times as many unions in 1881 as in 1877; and they were better organized "than in the most flourishing days of the past."[44] Organization among the coal miners was practically destroyed by the period of hard times.

> John Siney died of grief and hunger in 1876, and with him all organization among the men.[45]

The Knights of St. Crispin and the Daughters of St. Crispin also practically disappeared with the panic.

Up to 1875 as a rule, labor leaders opposed the use of the strike except as a last resort. President Siney of the National Miners' Association stated that one of the objects of the association was "to remove as far as possible the cause of all strikes." In 1877, the first great railway strike occurred, and many bitter contests took place in the cigarmaking industry. And after 1877, "strikes multiplied enormously."[46]

The middle years of the decade of the eighties were years of discontent and struggle. The competitive battle was extremely fierce. Many independent industries and proprietors were being ruthlessly crushed in order that industrial "American Beauty roses" might flourish; and in the process the employee inevitably suffered. The employer no longer came in personal touch with his employees; and the old personal relations no longer existed to soften and humanize the treatment of his employees. On the other hand, where the unions were in control, "the methods employed were not always diplomatic, and sometimes they were a bit coarse."[47] This big-stick policy reached its climax in some of the western mining towns the government of which was con-

[43] Simonds, "The Story of Manual Labor in all Ages," p. 661.

[44] *Cigarmakers' Official Journal*, March 10, 1881.

[45] Simonds, "The Story of Manual Labor in all Ages," p. 661.

[46] Swinton, "Striking for Life or Labor's Side of the Labor Question."

[47] Buchanan, "The Story of a Labor Agitator."

trolled by the unions.[48] The dark pictures painted by the labor leaders of the decade should be studied.

> Absorbed in the task of getting large dividends, the employer seldom inquired of his superintendent how he managed the business intrusted to his keeping, or how he treated the employees. In thousands of places throughout the United States, as many superintendents, foremen or petty bosses are interested in stores, corner groceries or saloons. In many places the employee is told plainly that he must deal at the store, or get his liquor from the saloon in which his boss has an interest; in others he is given to understand that he must deal in these stores or saloons, or forfeit his situation.[49]
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> Worse conditions never existed in any industry in this country than those of the Hocking Valley region of Ohio in 1884. Slavery was heaven compared with what the miners of the Hocking Valley had to endure.[50]

A new era was in the making; and the wage earners were being prepared for more definite and firm organization. But it was also a period in which capitalism was becoming strong and immigration was multiplying. The old individualistic ideals were still generally accepted; and were not displaced without much social friction. Strikes were of frequent occurrence and the boycott a popular weapon.

> The fall and winter of 1884 will long be remembered by men active in the labor movement at that time as a period of great stress. Strikes and lockouts were prevalent as never before in this country, and labor was often a heavy loser. Capitalism was beginning to look upon the militia as its natural ally, and labor was not sufficiently well organized to make politicians who had charge of the state machinery respect or fear its power.[51]
>
> What is the spectacle presented to our view? Crime reaching a magnitude it never did before; poverty increasing with frightful rapidity; intense and steadily increasing competition with labor in nearly every vocation of industry; an army of idlers crowding upon the workers everywhere; the man who is driven by necessity or want to work or die of starvation is compelled to fight his own fellows or be guarded by the police in the discharge of his duties. A decrepit, homeless humanity, swelling in numbers every day, audible groans of want, woe and misery coming up from every mining, manufacturing and commercial district, and from many agricultural districts throughout the civilized world. Strikes on every hand and general discontent prevailing.[52]

Finally, what would to-day be called "direct action" was advocated, and the Haymarket Square episode followed. The decade of the eighties was an era of capitalistic combination in the form of "pools"; but the spirit of solidarity among the wage earners was still very weak. The "separating influences of shops in one town, theories about general principles, language, nationality, or the division of labor, split the workers on one and the same product into bickering factions."[53]

[48] Cherouny, "The Historical Development of the Labor Question," pp. 240–244.

[49] Powderly in "Labor: Its Rights and Wrongs" (1886). Also, in *North American Review*, May, 1886.

[50] Buchanan, "The Story of a Labor Agitator."

[51] *Ibid.*, p. 128.

[52] Morgan, "History of the Wheel and Alliance," p. 662 (1889).

[53] Cherouny, "The Historical Development of the Labor Question."

The variety of political reform movements, their weakness and lack of harmony are indicative of the bankruptcy of the reform movements of the type then prevailing. *Truth,* "A Journal for the Poor," and a radical paper, declared:

This journal is not the paid mouthpiece of either Trades' Unions, Knights of Labor, Anti-Monopoly Party, Greenback Party, Socialistic Labor Party, Liberal League, Patrons of Husbandry (Grangers), Farmers' Alliance, Irish Revolutionary Organizations, or any other Nihilistic, Communal or Socialistic organization. But it is the friend of every one of them.[54]

Buchanan speaks of the lack of harmony in the ranks of the labor and reform forces of this period. In 1888, as editor of the *Chicago Enquirer,* he pled for a union among the following movements: "The Union Labor Party, United Labor Party, Progressive Labor Party, American Reform Party, the Grange, the Farmer's Alliance, the Tax Reformers, Anti-Monopolists, Homesteaders, and all other political and politico-economic organizations of bread-winners." [55]

Nevertheless, labor organizations were gaining in strength. The Knights of Labor reached its high water mark in 1886; and the American Federation of Labor increased from less than 50,000 in 1881 to over 200,000 in 1889. In an address sent by the heads of several trade unions to the convention of the Knights of Labor in 1886, it was confidently asserted that "within the past year the national and international trades unions have grown with giant strides." The following statistics of growth during the preceding year were offered:[56]

	Members
International Typographical Union has gained	9,642
Cigarmakers' International Union has gained	7,101
Brotherhood of Carpenters and Joiners has gained	13,464
International Union of Bricklayers and Masons has gained.	9,578
National Bakers' Union has gained	7,564
Furniture Workers' Union has gained	6,633
Amalgamated Iron and Steel Workers has gained	8,230
Iron Molders' Union has gained	12,400
Granite Cutters' Union has gained	3,622
Custom Tailors have gained	2,541
Coal Miners have gained	36,000

Labor was sloughing off its reformism and returning to the "pure and simple" type of trade unionism. Its was evidently becoming more difficult to lead the wage earners into the camp of the reformers.

During the period under consideration, employers' associations hostile to organized labor were by no means unknown. In July, 1872, "The Employers' Central Executive Committee" of New York City sent out a *questionnaire* containing eleven questions. The committee desired "to avail itself of the wisdom and experience of Thinkers and Em-

[54] September 15, 1883, Vol. 7.

[55] "Story of a Labor Agitator," p. 429.

[56] "Labor: Its Rights and Wrongs" (1886).

ployers," and hoped to be able to solve the difficulties arising because of combinations of workingmen. The prevention of strikes seemed to be one important problem. The seventh question asked whether unionists had given trouble and whether it would be easy to displace them. The eight read: "What Restrictions are imposed upon you as an Employer by Combinations of workmen assuming to regulate the pay or other conditions of Labor?" Another circular letter emanating from the same source requested employers to meet personally with the executive committee. This committee "are in session every day from 10 o'clock A.M. to 10 o'clock P.M." [57] There is reason to believe that this employers' association was not a weak organization. In a speech given at a mass meeting held in New York City in June, 1876, a member of the "executive committee of the Independent Labor Party" said:

> Less than five years ago we had over 79,000 organized men in the city; but 200 or 300 men gathered together in a hotel on Fifth Ave., combined against you by using the government, by going to Albany, to Washington, and to the Board of Aldermen. They have destroyed the Trade Union system, and reduced the workmen of the city to a condition of beggary and starvation.

The employers' associations of the seventies and eighties used many of the weapons which similar bodies of a more recent date have frequently used—blacklist, detectives, coal and iron police, the labor spy, promotion of labor leaders in order to weaken the union, discharge of union men, and the like.[58]

In conclusion, the chief peculiarities of the labor movements of the quarter of a century, 1866–1889, may be briefly summarized:

1. Unstable—ebbed and flowed with industrial changes and disputes.
2. Undisciplined—demanded of leaders immediate and strenuous action. Many strikes, usually of short duration.
3. No very definite class consciousness, except in the eighties. The chief demands were of the purely trade-union type—higher wages, shorter hours, better working and living conditions, etc.—for political reform—elimination of money or land monopoly, labor bureaus, etc.—or for cooperation.
4. Time after time leaders asserted that a transition period was just ahead and that especial efforts were needed at that particular time and place.
5. Repeatedly the attention is directed to the concentration of wealth and the growing menace of monopoly power.
6. The labor leaders of the period were muckrakers; they attacked the political rottenness of the time.
7. Immigration of Chinese laborers (coolies) was feared—not only in the west but also in the east.
8. Many persistent, but futile, attempts were made to weld labor into a strong political party.

[57] Circulars in New York Public Library.

[58] McNeill, "The Labor Movement," p. 266.

THE SCIENCE OF EDUCATION[1]

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I WANT you to understand that we have established some fundamental principles in our science: (1) A subject must interest a pupil. (2) A man who trains dogs or seals or bears or other animals makes a close study of their minds. In the same way we must recognize that one boy differs from another, and study the mind of each boy. (3) If a boy is not very receptive of an important subject we must do our best with him and try to settle what is the minimum with which we ought to be satisfied. Only a few subjects ought to be compulsory on all boys. (4) There are two classes of boys unequal as to numbers, (*a*) those fond of, and (*b*) those not capable of abstract reasoning. (5) Another two classes are (*a*) those fond of, and (*b*) those not fond of language study. (6) Every boy may be made to write and read in his own language and he may be made fond of reading. (7) The average boy's reasoning faculties are most surely developed by letting him do things. That is, for example, through his sports, or through wood or metal working, or gardening, or experiments involving weighing and measuring. Through the last of these he learns to compute. A boy of eight learns decimals in an hour if he weighs and measures, whereas by the usual method of teaching he is ignorant of decimals at the age of fourteen. A boy learns whist very quickly if you seat him with three other people at a table with a pack of cards; he would not learn in a month if he had no cards. Would you teach a boy to swim by mere talk? (8) Every boy must get a good deal of personal attention. (9) However good a system may be there can be no good results if the teachers are cheap; cheap teachers are usually stupid and over-worked. Men in charge of schools and colleges never seem to learn this. The market price must be paid for a capable man. (10) Fairly good results may be expected from a good teacher, even when he is compelled to work on a bad system, but really good results can be obtainable only from a good teacher with a good system.

I need not go into details about all these principles, but I should like to dwell presently upon a few of them. At the beginning of this address I spoke of the obstruction to great necessary reform—too much antiquated machinery to "scrap." Most schoolmasters will admit the necessity for reform in the case of the average boy, but they say that parents

[1] From the address of the president of the Educational Science Section of the British Association for the Advancement of Science, Australia, 1914.

are opposed to the reform. Unbelief in education for the average man is so general among the higher classes that I am afraid we shall have no reform unless some great national disaster causes conversion. There is a lesson for England, and, indeed, for all European races, in the recent history of Japan. The old structure of Japan was in many ways beautiful, but it proved to be without physical strength. Its extreme weakness proved its salvation. Even the teachers of ancient classics saw that for strength it was necessary to let scientific method permeate the thought of the whole population. And now, at the end of the first chapter of Japan's modern history, we find a nation which can not only defend itself, but which retains all of its spiritual life which was beautiful. Every unit of the population can not only read and write, but it is fond of reading, and its education did not cease when it left school. It is getting an increased love for natural science, so that it can reason clearly; it is not carried away by charlatans; it retains its individuality. One result of this is that in time of war Japan has scientific armies. Not only are its admirals and generals scientific, but also every officer, every private is scientific. Everything in the whole country is being developed scientifically, and we Europeans, hag-ridden by pedantry in our schools and universities, refuse to learn an easy lesson. At present we do not even ask what is meant by education or what education is necessary if a particular boy is to be fitted for his life's work. In 1902, when I was President of Section G, and in opening a discussion on the teaching of mechanics at Johannesburg in 1905, I gave my views as to the teaching of a young engineer, but they apply also to the teaching of nearly all boys. These views have been commended by experienced engineers and teachers. To understand me it is first necessary to try to cast away prejudices, and this is especially difficult if one has a pecuniary interest in education. The student of almost any other science than education cares for nothing but the truth; even when he has committed himself to a theory and his good name or credit is at stake the rule of the game is perfectly well known and must be adhered to. The student must not neglect fact or pervert fact; he must be quite fair. The student of physical science sees at once whether or not he is playing the game, because the coordinates are few; there are no complexities, such as we find in our own life problems. This also is why the study of physical science is so good in causing boys to reason, for reasoning can only be taught by constant practise on simple matters which one thoroughly comprehends. Consider a boy's views about ordinary affairs. He is downright. A complex thing must be greatly simplified to him. His painting is in black-and-white; there is no delicate shading in his picture. He never sits on the fence; he is never a trimmer. An historical character is awfully good or awfully bad, very clever or very stupid. A boy is, in fact, cocksure about everything. He is incapable of reasoning about complex things. And when we try to teach him to

reason about simple things we must be quite sure that they really are simple to him, that he understands them. For example, many educationists say that the study of geometry is just right for a boy. Well, yes, for five per cent. of all boys, boys who can take in abstract ideas. They take to Euclid as a duck takes to water. But for the other ninety-five per cent. geometry is very hurtful, because unless they continually experiment with rulers and compasses they do not understand what the reasoning is about. In ancient times only very old and exceptionally clever men were allowed to study geometry. We now assume that it ought to be an easy study for the average English boy. Generation after generation we stupefy the average English boy with demonstrative geometry, and we call him a duffer so often that he thinks himself a duffer, and even his mother thinks him a duffer, and, indeed, we have done our best with geometry and Latin to make him a duffer. Only for his football and cricket, which teach him to reason a little, he would become a duffer. And yet in my opinion if this average boy were properly taught in school he would prove to be very superior to the boy who is usually called clever. The schoolmaster calls a boy clever because he is exactly like what the schoolmaster himself was when a boy; but I am afraid that I place little value on the schoolmaster's cleverness, whether as a boy or a man. Reasoning can be taught through almost anything that a boy does, but more than all things through his experiments in natural science. Formal lessons on reasoning, on logic, are utterly useless, and I may say that set lessons on almost any subject are utterly useless for the average boy.

Milton's poems are greatly praised. Well, I am not going to say a word against the people who talk in public about the most wonderful epic in our language and who never read it; but how many people have read Milton's magnificent prose works? Milton first taught me the true notion of education, that the greatest mistake is in teaching subjects in watertight compartments. It is the idea underlying one of the most instructive books ever written, "Sandford and Merton." When teaching a subject, teach all sorts of other subjects as well. If Mr. Barlow's boys were interested in astronomy he showed them stars and planets through a telescope for a night or two, but he gave them no stupefying course on astronomy. He gave them stars and the solar system just as long as they were interested. He used a globe as well as mere maps in teaching them geography and history, but the soul-destroying idea of a course of study on "the use of the globes" did not commend itself to him. They walked over the fields and took an interest in trees and flowers, but he gave them no stupefying course on botany. When he gave them a lesson on English grammar or literature he taught them at the same time the geography and history and the fairy stories of their country. How can a man give a course on grammar or geography or history or anything else without diverting his talk in an interesting way

to other subjects? What is so tremendously important about natural science laboratory work is that a student must be thinking all the time about the same matters, not from one but from ten interesting points of view. He is not merely observing, he is measuring, he is computing, he is reasoning; he has to write out descriptions of what he sees and does, and he thinks then of his spelling and grammar; he has to sketch; he has to read books about what other people have done before him on the same subject, and also for statistics. He learns the value of a bit of work done in a clean honest way, and when he gets some more experience he glows with the feeling that he has really added to the knowledge of the world. He is a discoverer, and he feels the emotion of Cortez! It is marvelous the alteration which has occurred in the mental attitude of the common average boy. Instead of feeling that he is a degraded slave he feels the emotion of his childhood returning to him. He once made the great discovery at the age of six that the back garden was inhabited by fairies and lions and Indians and pirates. He was the Caliph Haroun Alraschid for a while. And now, after a wretched life at Latin and Euclid, a new revelation is vouchsafed to him, and as he gathers years he finds that nature is placidly willing to let him steal her secrets little by little, one by one, secrets that are gradually changing men from the bewilderment and spirit possession of the Middle Ages; so that at length he enters into complete communion with nature and rollicks with her, and quarrels with her, and loves her more and more until he dies. And his reasoning power has been growing all the time, so that more and more he understands complex things, for, after an experimental study of story-books, he probably entered the kingdom of Shakespeare at the age of fourteen. Things requiring memory can be learned only in early life—weights and measures, the multiplication table, languages. He knows games involving spelling. But, over and above all these, he has from infancy repeated all sorts of poetry long before he could enjoy much more of it than the jingle of its rhyme.

Education consists in the development of a man from his earliest day, and does not cease till he dies. Any thoughtful man must see that there is no science so important as that of education, the preparation of children of this generation to be the citizens, the rulers of the country, in the next generation. The whole future of our Empire depends upon the education of the children. By the study of this science we hope to improve teaching so as to make future citizens not only to have more knowledge and more skill, but to make them wiser than the people of the present or the past.

Early training determines what later training ought to be. Let us consider what the early training of a boy ought to be. In his very early days nature has provided that his education shall proceed very rapidly by observation and experiment, and the only teaching needed is through careful nursing and affection. He teaches himself, and he loves

to learn. He ought to get toys not too realistic, for he loves to weave romance around his toys, but still things to observe and experiment with. He has most complex problems in physical science when he is only a few weeks old, the solution of which involves much labor, but it is pleasant labor and he is happy. And he will remain sweet-tempered and happy and unspoilt if there is real affection from his teachers. If, however, somebody teases him by playing practical jokes, or if a selfish mother who was unreasonably kind to him yesterday is unreasonably unkind to him to-day, he gets, because of his reasoning power, a sense of injustice. Man, woman, or child with a sense of injustice may be said to be possessed of a devil. During the first six years of a child's life the creation of its power to reason is more wonderful than anything else, and this reasoning power comes altogether by observation and experiment. An affectionate parent easily finds methods of helping nature in this process. The unspoilt boy of six years seems to forget nothing that he hears; he has gathered a most wonderful vocabulary; he knows endless nursery rhymes and simple poetry; he is as active and adventurous as a kitten, and everything he does is cultivating his senses. This is the time when he fills the smallest playground (which to grown-ups seems bare and desolate) with giants and fairies and Indians and pirates, with forests and mountains and rivers and oceans. His imagination is so extraordinary that the most uncouth creation of his own gives him exquisite pleasure. Why do I dwell upon this stage of a boy's development? Because it has been so perfect! Nature has learned to do this to children during perhaps hundreds of thousands of years, and it has been the most important time of a boy's life, the time when, if parents will only give the boy their love and greatly let him alone otherwise, he develops mentally more than during all the rest of his life. Speaking broadly, he has done nothing in all this time except what nature and affection made pleasant to him. I have studied the science of education and practised the art of teaching all my life, and I say that all our failures are due to our neglect of nature's methods, and our schools destroy the good effects which nature has produced.

As a rule I do not like to be told that certain subjects must be compulsory, but surely every child of eleven must have some such qualifications as these: (1) The power to speak and read and write in his own language. (2) To be able to do easy computation. (3) To have an exact knowledge of the simplest principles of natural science from his own observation and experiment. I think that every observer must acknowledge that these powers are possible for almost every boy of eleven. Some of us have for many years been endeavoring to show how the child of six may acquire these powers by the age of eleven if nature's methods—that is, kindergarten methods—are followed. For example, he plays at keeping shop, selling or buying things by weight and measure, and paying or receiving actual money and giving change. He weighs and meas-

ures with greater and greater accuracy as he makes experiments in mechanics and heat and chemistry. Every boy is fond of stories, and if treated reasonably is easily induced to learn to read. Reading aloud is easily made a pleasure and a habit, and so the boy learns to speak properly. Any boy whatever will become fond of reading if the people about him are fond of reading: I state this as a fact which I have investigated. A boy who is fond of reading gets later on to know the value of books and the use of books, and he will go on educating himself till he dies. Any attempt at coercion, unless it is the very gentle coercion of a person whom he loves, is fatal; even coaxing is not always good. He assimilates knowledge from everything which he does, and therefore he ought to be induced to do things which not only keep him healthy, but which give him knowledge and teach him to reason. Do you remember how angry Lanfranc of Bec was at the idea that any pupil could be *forced* to learn; he said "it turned men into beasts." I speak to you who love children, who love young people, who know that there is hardly one child in a hundred, even among rather spoilt children, who does not love to do his duty.

Under the best and most loving of teachers a lonely child has enormous disadvantages, but these can generally be remedied. The usual mistake is to send it to a large school. If it is merely a day school there is no great harm. But no child under thirteen ought to be sent to a boarding school unless it is a small school and the master and his wife have a love and sympathy for other people's children. There are such people in the world, God bless them! but they are not numerous. They are so few that we must return to nature as the best of teachers. The time is coming when a child's own father and mother will have much more knowledge and wisdom than they have now, and they will refuse to give up to others the doing of their highest duties. It is at present not sufficiently recognized that the most important duty of the parents is the education of their children. At present, men who are building up fortunes are too busy to think of their children, and so we find that the sons of Lord Chancellors and other successful men have been marrying chorus girls and squandering those very fortunes to which their education was sacrificed. Of course, if parents are uneducated, and therefore selfish or otherwise foolish, any kind of school may be better than home for their doomed children. It is one of the great advantages of poverty that the children go to day schools and they keep in touch with home life. If the day school is really a boarding school as well, it will be found that there is always a differentiation in favor of the boarder, which has a very bad caste effect, just as the "modern-side" boy of any public school suffers in character because he is of a lower caste than the classical-side boy. It is usual to remove a stupid classical-side boy to the modern side, and every boy on the modern side has a sense of injustice. The

work of the modern side ought to be much the higher, but it is always badly done because the atmosphere is altogether bad.

It may be said that I am only destructive in my criticism of public schools. I think it will be found that I am also constructive, although I acknowledge that my sketch needs much filling in. Well, can much more be done in an address lasting one hour? I will now try my hand at a little filling in. I have no objection to the existence of classical schools something like the present for boys who are fond of classics. The average boy will not be asked to attend such a school. I feel sure that much greater attention ought to be paid to the teaching of English composition, to English poetry and prose, and to English subjects generally. I also feel sure that much attention ought to be paid to natural science. And surely it can do no good for the classical masters to go on sneering at natural science subjects and calling them "stinks" as they do now.

I want, however, to speak more particularly of a much higher kind of school, which will educate the boy usually called clever and also the boy usually called stupid. As I have already remarked, I think that these names may sometimes be redistributed.

The school is one for boys from eleven to sixteen years of age. It ought in no way to be connected with any classical school. English subjects will predominate, but teaching in Latin and Greek and modern languages and other alternative subjects will be provided, although they will not be forced upon any boy. The masters who teach English ought to know enough Latin and Greek and Celtic and Old English and modern languages to be able to illustrate the derivation of English words through their roots. And they must be well read in English subjects and fond of English literature. They will make the boys fond of reading English, and encourage them to find out what they like best. Some boys will take to history and philosophy, some to poetry and imaginative literature. Every boy ought to get the best chance of developing his faculties. It may be asked—if we can not make the average boy spend or waste twelve hours a week on Latin, what are we to do with him? At all events, now, we keep him doing something, even if it is only marking time. My answer is, you think only of his putting in time; well, then, let him put in his time at work that interests him; any work of that kind must be educative under an intelligent master who can help him in his studies if it induces him to look up information for himself. Thus, when reading travels or history, he will use the globe and raised maps and read geography, and hunt up plans of battlefields. Think of the things that a boy used to be punished for doing, and let him do those things under wise direction. I used to be punished for reading Scott and Cooper. Nowadays prizes are given to boys for their knowledge of Ivanhoe or Quentin Durward. Expand this into a system. A boy who loves to browse over Chambers' English literature ought to be guided

in his browsing, and induced to take up something more than selections, and he may easily be induced to get off selections by heart if his teacher does not show his contempt by speaking of such exercises as *Rep.* [repetition].

Let the teacher take a leaf out of our methods of teaching chemistry and physics. It has been shown that twenty-five boys doing work in the laboratory during a lesson of an hour and a half or two hours can be managed by one teacher. Experimental lectures in a lecture room have now been greatly discarded; such lessons as I speak of take place in the laboratory, but reliance is placed particularly upon the personal attention of the teacher being given to each group of students in charge of an investigation, the group not being usually greater than four in number, and often being less than two. These students are sometimes merely verifying or testing a statement made by the teacher or found in a book, but they are often finding out things for themselves. One idea underlying the work is that there ought to be more and more illustrations of simple fundamental principles. It is long before these simple things really become part of a boy's mental machinery; things like the mere definition of *force,* for example. It is, of course, quite different work for the teacher from anything that he used to have to do; for one thing, being much more exhausting. He can not shirk his duties and sit down waiting for students to come to him. When teaching degenerates into mere maintenance of discipline, everything being regarded as right if the pupils are quiet and seem to be diligent, it is necessary to make a radical change, usually a dismissal of the teacher. It used to be that a science master gave an experimental lecture, and afterwards he had a very easy time, letting the students follow a set routine in the laboratory, but this will no longer do; such attendance at lectures and laboratory work means poor mental training.

Now, I would work out a system for English, English composition, English poetry and prose, geography, history and other English subjects, on the lines that we have found so successful in natural science. An enormous change has been effected during the last fifteen years in the teaching of mathematics. The older methods always failed with the average boy or man. The new system, which is sometimes called *practical* mathematics, is based on the idea that students shall work experimentally, just as they do in their natural science. It is found that their eyes and faces are bright, they work hard, and they evidently enjoy their work. We have merely introduced common sense into the teaching; we have approached the student's mind from other points of view than the old academic one, from the only side on which he has ever been taught anything—the side of observation and trial. He weighs and measures. He does experimental geometry and mensuration, and is assisted by abstract reasoning just to the extent which interests him; he makes plans of the school buildings and maps of the district; algebra

becomes interesting when in coordination with experiments in mechanics and physics; trigonometry becomes interesting in the actual measurements of heights and distances. The infinitesimal calculus is bound to be a weapon which any boy of fifteen easily gets to understand by actual use when he is dealing with dynamic experiments. In fact, the physical and mathematical laboratories are in one, and the same teacher takes charge of both subjects and teaches them as much as possible together.

Furthermore, in the preparation of an account of an investigation there are practical lessons in English composition; there is sketching, and also more careful drawing with instruments, and the finding of empirical laws, using squared paper. In such a school every subject is being taught through all the other subjects; every boy is doing the work in which he is greatly interested, and no boy is attending merely and putting in time. Furthermore, out of school-time there might be the usual restrictions as to "bounds," but otherwise I would let a boy do pretty much as he pleased. "Prep." at boarding schools and home lessons for boys at day schools are to be quite discredited. I would—it may cost a little more money—allow a boy to work in the workshops or laboratories or library or in his own room or common rooms at anything he pleases in this off-time, and I would give him advice only if he asks for it. If I saw a boy reading a penny dreadful I would not stop him; nor if he were reading Paine's "Age of Reason," or any wretched treatise on psychology or logic. I would in no way discourage a boy from acquiring a greater and greater fondness for reading, knowing that this is the foundation of future happiness and education, and that no harm which he can get from his reading is of the slightest importance in comparison with the importance of our main object. As he grows up he will become less and less fond of the sixpenny magazine. The school can at its best be merely a preparation for the lifelong education of the man. I would not keep the boy at school after sixteen. Let him then go into business, or to a science or technical school, or to the university.

Unfortunately for the present no university will take men without an entrance examination involving other languages than English. This is a great evil, but it is not going to last much longer. In the meantime a competent coach will prepare any student to pass the necessary examinations (say, in Latin and Greek) in three months, even if there is much other work to do. This is not a matter of learning any classics; it is rather the manufacture of some contempt for the classics, a necessary evil for the present. Indeed, for the present, but let us hope not for long, there are many other necessary evils. We have to find competent enthusiastic teachers, we have to persuade governing bodies to pay salaries two or more times as great as at present, we have to make parents see that some mental training and fondness for reading and writing are really of value, and that Tom Sawyerism is only childish.

The importance of primary education is now well recognized. Rich and aristocratic folk know that they are now in the hands of the common people in a democratic country, and it is important to see that the common people shall be made fit to rule and shall have a real sense of fairness and reasonableness. Above all, if they are to be good citizens we must cultivate their common sense. I think that in the schemes and the administration of primary education by the Boards of England and Scotland it is in a good way; but there is one great curse upon it, and the enormous sums of money spent upon it are greatly wasted. The local authorities give to every teacher far too much to do, and they give him only half his proper wages. In a few years the government of our democratic country will be in the hands of the boys now at school. That they should be good citizens full of common sense is more important than any other thing. If they are without fondness for books, and if they can not reason, their votes will be at the command of fraudulent or foolish, or perhaps only selfish or self-deceiving speakers. Our empire was ruled by George the Third, and by God's grace we only lost America and piled up the national debt; but think of an empire ruled by millions of Georges! Teaching the young requires great wisdom and sympathy, and we trust it to people paid half wages, the "otherwise unemployed." In the secondary schools also we find this penny wise pound foolish policy, and it is particularly evil in the great technical schools. A city is proud of its magnificent college of science, first because of its architecture; secondly, because of its equipment in apparatus, perhaps in steam and gas engines and other expensive machinery. And the man in charge of the most important department of that college receives perhaps £250 a year. He ought to get at least £600. That is the market price of a fit man, and without a fit man the whole money and the time of students are being wasted; the thing is really a fraud, a whited sepulcher, and of course the principal is always a classical non-scientific man. Photographs of the building and its laboratories are very fine to look at in guide-books of the city, and the managers of the college get public thanks for their services. I know nearly all the technical and science colleges of Great Britain, and I hardly ever see any of their complacent managers, members of their governing bodies, without wishing that I had some of the powers of the familiars of the old Spanish Inquisition. What right have they to undertake duties which require a knowledge of natural science?

The latest proposal of our callous copiers of the Germans is to make attendance at evening classes compulsory up to the age of seventeen. At present working boys attend evening classes voluntarily, although in many cases they are too tired to learn much. Yet many of them do learn. These boys are almost martyrs. They sacrifice so many of their poor pleasures, and indeed duties, that they certainly deserve success in

life. But it is not fair to impose these sacrifices upon boys who are, as apprentices, learning the principles underlying their trade, and who are paid only small wages on the understanding that their masters teach these principles. In 1889 I introduced a bill into the Kensington Parliament compelling employers to provide such instruction during the working hours. Reforms of all kinds proceed with exasperating slowness, but already many employers are carrying out this idea.

In some things we reformers have made way. It is now recognized almost everywhere that examinations ought to be conducted mainly by the teachers of a student. I have often put the matter in this way: Huxley used to teach about forty students in biology; we can not imagine better teaching. But if those students had only wanted to pass the examination of London University it is quite certain that they would have done very much better by attending the class of a cheap crammer. A university consisting of two, three, or more federated colleges is very little better than a mere outside examining body, and this is what London University has always been. I am glad that a change towards something better is now about to take place. A number of separate universities would be better, but in two years or less, probably, the colleges of London will conduct their own intermediate and degree examinations. One result will be that when a man gets his degree he will not shut up his books forever.

I would, however, point out that Old London University, which was a mere examining body, served an exceedingly important purpose. This statement may seem curious coming from a person who has always railed at London University as a mere examining board. I still say that it was never a university at all in the past. But a man reading hard by himself, perhaps far away from a college, could have a severe test applied to his acquirements which encouraged him in his studies when he had no other encouragement, and the test was very rightly a severe test. To do away with its outside examinations altogether, as I believe is the intention of the authorities, will be exceedingly harmful. It would be impertinent in me to make a suggestion as to the distinction which might be made between a degree conferred by his own professors upon a man who has attended regularly a college of repute, and a degree conferred by a mere examining body upon an outside student. For the first, the examination test may be easy. The Oxford and Cambridge pass degree examinations are quite easy, and rightly so, for the real qualification is that an undergraduate shall have lived for three years in the intellectual and cultured life of an Oxford or Cambridge college. In the other case the mere examination is the only test, and it is rightly very severe. The two kinds of degree differ altogether in quality. In a new country of great distances I can imagine many good secondary schools to be established having neither sufficient funds nor sufficient pupils to be qualified as universities. Yet it may be of enormous importance that

a few of the older pupils at such schools should as external students be examined for degrees by distant universities, which in such a case, are merely outside examining bodies. I can see the gradual increase in importance of such secondary schools leading to the establishment of something higher—namely, colleges of university rank—and I can see such affiliated colleges becoming universities themselves perhaps after a period in which two or more of them federated themselves as universities. But I say that there ought always to be some examination machinery by which a student who is too poor or who through any other circumstance is unable to attend a university college may be encouraged to study by himself, by having his attainments tested.

In this address I have said nothing about the education of women. I have always advocated higher education for girls, but it is surely wicked to teach girls as if they were boys. Men are concentrative, and they specialize; women observe more and more about many things, and they really have more capacity for acquiring mental power. Until quite recently girls were saved from stupidity, but the high schools are now giving a crammed knowledge of facts and of the opinions of the tribe, so that girls and women are ceasing to think for themselves. The education of men is in a bad way, but that of women is becoming much worse.

I think that in this address I have put forward no idea that I have not already published time after time in the last thirty-five years. I put these views forward again because, after much thought and much experience, I still think them to be correct, and I feel sure that they must prevail. But I must confess that it is only a very hopeful man who can peg away at a thankless task as Dr. Armstrong and I have been doing so long.

THE PROGRESS OF SCIENCE

SCIENCE AND THE WAR

One of the most serious aspects of the war is the diversion from scientific work which it involves. Should the contributions to pure and applied science in the course of the next ten years be reduced to one half, the loss to the world in life and wealth would be far greater than that caused directly by the destruction of war. It may be guessed that in the course of the past hundred years the death-rate has been reduced to one half in the more civilized nations and the annual production of wealth has been increased by a hundred billion dollars. If a comparable advance would have been made in the next ten years apart from the war and this should be reduced to half as a result of the war, the loss would be so great as to be almost incredible. Thus the death rate in England has been reduced from 23 per thousand to 14 per thousand in the course of fifty years. If by the advances of science and civilization in the course of ten years the death rate would have been reduced to 12 per thousand and as the result of the war the reduction should be only to 11, so that for a period of ten years the death rate is one per thousand larger than it otherwise would have been, the deaths in England chargeable to the war apart from those directly caused by it would be in the neighborhood of 400,000 and in the civilized world of 4,000,000. There would be a corresponding excess of ill-health and disease over what would have been suffered had there been no war.

In like manner it may be calculated that if the increased production of the world's wealth which might have been expected from new applications of science should be decreased to one half by the war for a period of ten years the economic loss would be in the neighborhood of fifty billion dollars. These calculations are, of course, subject to a very large probable error. We may hope that the advance of science will not be checked to the extent of one half for a period of ten years. It has been said that it will be a generation before the nations involved will regain the position they now hold, but it may, on the contrary, be the case that the loss will be far less than is assumed as the basis of these calculations. It depends on the length of the war and on many other conditions of which we are ignorant.

But figures such as these, even though they have but small reliability, may impress on us the magnitude of the value of science for the world and the injury done by an interruption to its progress. A loss of four million lives and of fifty billion dollars from a slackening in scientific work due to the war is greater than the destruction which will be directly caused. While we are helpless in presence of the direct destruction from the war, this is not equally the case with the loss due to the failure in scientific research and the applications of science. We should in this country do what we can to carry forward the work which will be dropped by the disabled nations.

THE DISTRIBUTION OF SCIENTIFIC MEN AMONG THE DIFFERENT NATIONS

Some idea of the relative contributions to science by the different nations may be gathered from the number of scientific men recorded in "Who's Who in Science," an international biographical directory edited by H. H. Stephenson and published here by The Macmillan Company. In this compilation there are recorded 1,678 scientific men from the United

HERMANN VON HELMHOLTZ, the great German physiologist and physicist, and Frau von Helmholtz are seated in the center, on the left is Professor Hugo Kronecker, of Bern, the distinguished physiologist, whose death has recently occurred. In the center is Mr. Henry Villard; on the right, Dr. T. C. Mendenhall, the American physicist. We owe the photograph, which was taken in Washington in 1893, to Dr. S. J. Meltzer, of the Rockefeller Institute of Medical Research, a student and friend of Kronecker's.

States and 1,472 from Great Britain. These figures indicate that there are more scientific men in the United States than in Great Britain, practically all those from the latter country having been included. The work being an Anglo-American compilation, the numbers are not comparable with those of the continental nations, but there is perhaps no reason why any one of these should have been favored in the selection of names. In so far as this is the case, the numbers of scientific men of some distinction in the different countries are as follows: Germany, 1,280; France, 423; Austria-Hungary, 236; Italy, 215; Switzerland, 214; Holland, 155; Sweden, 109; Russia, 97; Denmark, 94; Belgium, 90; Norway, 88; Portugal, 49; Spain, 41. It thus appears that Germany has three times as many scientific men as France. The population of Germany is considerably larger, but this was not the case at the time the men were born, they being on the average about 50 years of age and practically none of them under forty. The number of men in France over 45 years is only about one million less than in Germany, though there are twice as many children in Germany.

In order to compare the smaller nations with the larger we must take account of their size. The numbers of scientific men for each million of the present populations of the different nations are as follows: Switzerland, 58; Norway, 37; Denmark, 34; Holland, 26; Sweden, 20; Germany, 19; Belgium, 12; France, 11; Portugal, 9; Italy, 6; Austria-Hungary, 5; Spain, 2; Russia 1. In this comparison the smaller nations show to advantage, and this is a factor that should be kept in mind in any redistribution of empire. Switzerland leads all other nations, followed by the Scandinavian countries and Holland. Belgium is before France, and Portugal is close to it. In so far as the production of scientific men is a measure of civilization, Austria-Hungary and Italy fare badly and Russia is far behind all other nations.

A study of the distribution of the more distinguished men of science was contributed to this journal (October, 1908) by Dr. E. C. Pickering, the director of the Harvard College Observatory. Taking the scientific men who were members of at least two foreign academies, they were distributed as follows: Germany, 29, France 12, England 13, the United States 6, Austria 4, Italy, Sweden, Holland, Norway, Denmark and Russia, 3 each. The recognition of scientific eminence is likely to come late in life and these men were mostly old; half of the six distinguished Americans—Agassiz, Hill and Newcomb—have since died. The present distribution of the foreign members of the National Academy of Sciences is as follows: German 18, Great Britain 11, France 4, Holland 4, Russia and Sweden, two each, Austria, Italy, Norway and Switzerland, one each. Here again France does not compare favorably with Germany. Among its four representatives are two distinguished mathematicians, Darboux and Picard, the other two being Deslandres, the astronomer, and Barrois, the paleontologist. They are scarcely the peers of the four Dutch representatives, Kapteyn, Lorenz, de Vries and van der Waals, and are apparently less distinguished than the Germans and the English.

If we select the greatest men from the list compiled by Dr. Pickering or from the foreign membership of the National Academy, it is not easy to find any who can be placed beside Helmholtz or Pasteur, whose portraits happen to be reproduced in this place. It may be an error of perspective that those nearer to us seem smaller. But when Germany names its greatest men it goes back to Goethe and Kant, and the scientific men who have died or have ceased their active work appear to be greater than those who are now filling the chairs in the universities.

This does not mean that present work in science is less important than

Louis Pasteur.

A replica of the bust by Dubois, presented to the American Museum of Natural History for installation in the hall of public health, through the generosity of Dr. Roux, director of the Pasteur Institute in Paris and M. Vallery-Radot, son-in-law of Pasteur.

it was formerly. It may be that in its earlier history, there was more opportunity for striking discoveries. The condition may also be explained by an inversion of the proverb "The forest can not be seen for the trees." There are now so many scientific men doing work of importance that it is impossible to remember even their names. "The trees can not be seen for the forest." Still, if we write the names of the leading scientific men of the last generation, beginning with Darwin in England, Pasteur in France and Helmholtz in Germany, beside those who have recently died or are still living at an advanced age, there seems to be a decline in distinction, and the same holds if this group is compared with scientific men who are now active. It is not easy to decide whether this is appearance or reality.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Morris Longstreth, formerly professor of pathological anatomy at Jefferson Medical College; of Dr. James Ellis Gow, professor of botany in Coe College; of Overton Westfield Price, at one time associate forester of the U. S. Forest Service; of Dr. W. H. Gaskell, university lecturer in physiology at Cambridge University and of Dr. Eugen von Böhm-Bawerk, professor of economics in the University of Vienna, formerly minister of finance, president of the Vienna Academy of Sciences.

An international committee has been formed to establish a foundation in memory of Henry Poincaré. A medal will be struck in his honor, and a fund will be established under the Paris Academy of Sciences to encourage or reward young scholars engaged in work in the directions in which Poincaré led, namely, mathematical analysis, celestial mechanics, mathematical physics and scientific philosophy.

Dr. A. Penck, professor of geography at Berlin; Dr. F. von Luschan, professor of anthropology in the same university, and Dr. J. Walther, professor of geology and paleontology at Halle, are among the German men of science who attended the Australasian meeting of the British Association. It is said that there is some anxiety as to how they shall return home. If press despatches are to be believed, several German astronomers, including Professors Kempff and Ludendorf, who had gone to the Crimea to observe the eclipse of the sun, have been taken prisoners and their scientific instruments confiscated.—Among the German scientific men who have affixed their names to a manifesto renouncing the honors conferred upon them by English universities and other learned institutions are Professors Paul Ehrlich, Emil von Behring, Ernst Haeckel, August Weismann and Wilhelm Wundt.

Sir Ernest Shackleton and the members of his Transantarctic Expedition left London on September 18 for the South Polar regions. The explorers departed in two sections, the portion for the Ross Sea or New Zealand side of the Antarctic leaving in the morning *via* Tilbury for Tasmania, and the Weddell Sea section, including Sir Ernest Shackleton, leaving for South America later in the day. The *Endurance*, the ship of the Weddell Sea party, left Plymouth on August 8. The Ross Sea ship *Aurora* is to leave some Australian port about the beginning of December.